

Symbols \Leftrightarrow Models

Alexander M. Duda

University of Illinois at Urbana-Champaign

Department of Electrical and Computer Engineering

Beckman Institute for Advanced Science and Technology

amduda@illinois.edu

1 Introduction

The hidden Markov model (HMM) has a strong ability to discover and represent linguistic structure from textual observations (see Levinson p. 107-108 [2]). Cave and Neuwirth used ordinary text from a newspaper as an observation sequence and showed that the HMM was successful at extracting some nontrivial linguistic properties of English text [1]. For instance, with four hidden states, the model successfully partitioned the letters into groups corresponding to vowels, consonants, and the inter-word space¹; the number of different partitions scaled with the number of hidden states used. In their original experiment they used 2, 3, ..., 12 hidden states and provided a discussion of what each model was able to discover. In the results that follow, we primarily focus on re-doing the experiments for 2, 3, ..., 7 hidden states². A modified Baum-Welch algorithm is able to solve for the HMM model $\lambda = (A, B, \pi)$. For the exact details of how this process is carried out, please see the discussion in Ch. 3 of Levinson [2], the HMM introduction by Poritz [4], and/or the code provided in Appendix E.

2 Classic Results: Symbols to Models

The following section provides the results of running the model with different numbers of hidden states. For each such number, the results are shown via diagrams. B is shown as a N -by- M matrix³ of grayscale pixels where black corresponds to a probability zero event and white corresponds to a probability 1 event. A pixel with a grayscale color in between corresponds to a probability value between zero and one. A is shown as a N -by- N matrix of grayscale pixels, as before. Beginning at the top of any given result, is shown the initial B and A ; the final B and A are given next; the log-likelihood plot is given last (where base 2 was used). We considered

¹For brevity, the inter-word space will be referred to as “#” throughout the document.

²This work was completed as Project 1 for Dr. Stephen E. Levinson’s ECE 594: Mathematical Models of Language, Spring 2013

³ N is the number of hidden states, which varies from 2 to 7. M is the number of symbols—fixed at 27 (the alphabetical symbols and #)

the model converged when, for a given iteration, the change for all model parameters ($\{a_{ij}\}, \{b_j(k)\}, \{\pi_i\}$) was below 1e-4. The interpretations below will focus on the final models.

Before getting to the actual results though, we point the interested reader to Tables located in Appendix A, which outlines English letter frequency counts Peter Norvig derived from the Google Corpus Data [3]; these statistics were derived from an observation sequence of length 3,563,505,777,820. Table 7 summarizes, in general, the frequency of a given letter being used. For the frequency of a given letter in a particular position in a word see Table 8 for $(1^{\text{st}}, \dots, 7^{\text{th}})$ and Table 9 for $(-7^{\text{th}}, \dots, -1^{\text{st}})$. We use data from the aforementioned tables as a “ground-truth”; it provides a means of analyzing our empirical results. For brevity, in the sections that follow, when we refer to the n^{th} column of Table 8, we use the notation T8.n (similarly for the other tables). Additionally, when referring to “hidden state n ” we write S_n . Furthermore, within the body of the text, a truncated version of B is given that shows only the ten most probable symbols for a given hidden state, organized in non-increasing order of probability. The final full A and B matrices are provided in Appendix B.

In the sections that follow, the results are discussed for various numbers of hidden states. In particular, we focus on the output generated by the model just by looking at A and B ; we examine the most likely first letter, second letter, last letter, and second-to-last letter and compare them to the “ground truth” (and general linguistic experience). We will focus primarily on the familiar aspects of English that the model identifies (like *vowels*, *consonants*, #, etc.). We will *not* focus as much on the limitations of the models during the initial discussion (though glaring limitations may be pointed out). The ultimate drawbacks of the models will be evaluated quantitatively in Section 3 via a very straightforward approach—the models will be used to generate text, which will be compared to the original text from which the models were derived, as well as the dictionary, to determine the extent to which the models were able to generate English; a success rate will be calculated that captures the number of English words generated.

2.1 Two Hidden States

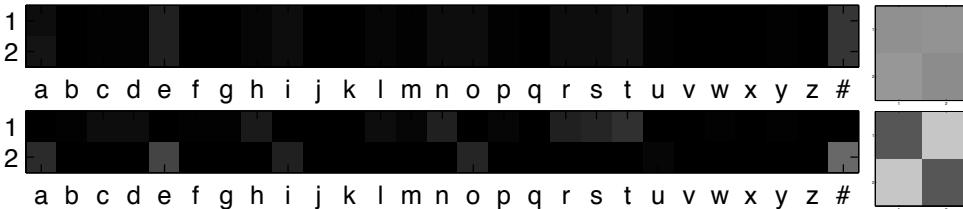


Figure 1: **Two Hidden States.** Above: B and A initial. Below: B and A final.

As Figure 2 shows, for two hidden states, it took 176 iterations for the model parameters to converge. As shown in Figure 1 and further emphasized by Table 1, B asserts that S_2 is dominated by vowels and includes $\#$; the amount of probability seems to scale well with well-known frequency data in English; in decreasing order of probability we have: $\#, e, a, o, i, u$. S_1 contains the consonants with most of the probability accounted for by: t, n, s, h, r (which are the most frequently used consonants). A shows that if we are in the consonant state we are very likely to transition to a vowel; if we are in a vowel state (or $\#$) we are very likely to transition to a consonant. This agrees with general linguistic experience with English.

Combining the results from A and B , we obtain the following observations:

First Letter. The first letters will be those that are likely to follow $\#$, which dominates S_2 . The most likely transition from S_2 is to S_1 (with t, s, r, n, h); the second most likely transition from S_2 is to S_2 (with e, a, o, i, u, c). Considering T8.1 shows that the most likely first letters are t, a, o, i, s, w, c , our result is reasonable but not spectacular.

Second Letter. The second letters will be those that are likely to follow the first letters, which can be from S_1 or S_2 . S_1 can transition to S_2 (to produce $te, ta, to, se, sa, re, ra$, etc.) or to S_1 (to produce tr, th, st, sh , etc.). S_2 can transition to S_1 (to produce et, es, er, at, as, ar , etc.). Such beginnings are common in English. Furthermore, as shown in T8.2, the most likely second letters are o, h, e, n, a, i, r , which matches well with our model result.

Last Letter. The last letter in a word will be those that occur before $\#$, which mean those letters in states transitioning to S_1 . S_2 is very likely to transition to S_1 (with t, s, r, n, h); S_1 can also transition to S_1 (with e, a, o, i, u). Considering T9.1 shows that the most likely last letters are e, s, d, n, t, y, r , our result is reasonable but not spectacular.

Second-to-Last Letter. The second-to-last letter in a word will be those that occur before the last letter; which mean those letters in states transitioning to S_2 or S_1 . S_1 is very likely to transition to S_2 (to produce te, ta, to, se, re, ne , etc.); S_2 can also transition to S_2 (to produce the less likely ee, ea, eo, oe, ia , etc.). S_2 is very likely to transition to S_1 (to produce $et, es, er, en, at, ar, on$, etc.); S_1 can also transition to S_1 (to produce ts, st, rt, rn, th , etc.). Such endings are common in

English. Furthermore, as shown in T9.-2, the most likely second-to-last letters are e, o, n, a, h, i, t, r , which matches well with our model result.

B Final	
1	2
t	#
s	e
r	a
n	o
h	I
l	u
d	c
c	l
m	t
p	y

Table 1: **Two Hidden States B Truncated.** Here we show the ten most likely symbols for each state, arranged in non-increasing order of probability.

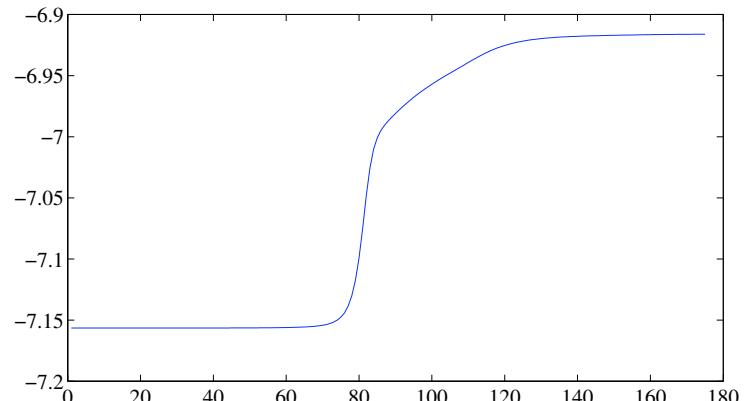


Figure 2: **Two Hidden States Convergence.** The log-likelihood plot is shown (where base 2 was used), which clearly levels off after 176 iterations, which is the time at which all model parameters changed less than 1e-4.

2.2 Three Hidden States

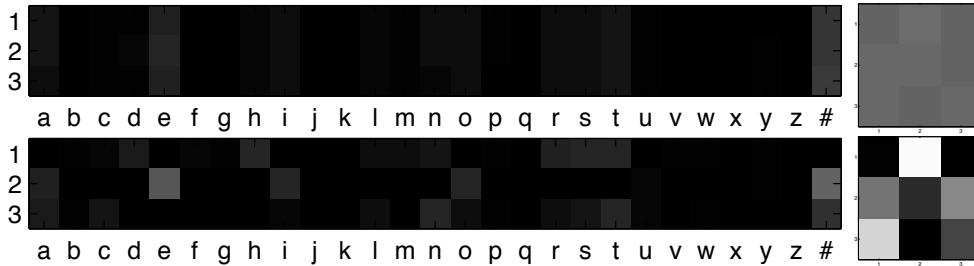


Figure 3: **Three Hidden States.** Above: B and A initial. Below: B and A final.

As Figure 4 shows, for three hidden states, it took 282 iterations for the model parameters to converge. As shown in Figure 3 and further emphasized by Table 2, *B* asserts that S_1 is dominated by consonants; S_2 is dominated by vowels (with their probability in almost the same order (e, o, i, a, u) as T7 and $\#$); S_3 is dominated by $\#$, consonants t, n, s, c and vowels a, o, etc . From *A*, we observe that S_1 transitions to S_2 ; S_2 transitions to S_3 , S_1 , and S_2 ; S_3 transitions to S_1 , S_3 , or S_2 . With the presence of $\#$ in two different states it seems to make shorter words more likely.

Combining the results from *A* and *B*, we now examine some of the results in more detail and obtain the following observations:

First Letter. The first letters will be those that are likely to follow $\#$, which dominates S_2 and S_3 . The most likely transitions from S_2 (in decreasing order) are S_3 (with t, a , and s matching well with T8.1), S_1 (with t, s , and h among the more likely in T8.1), and S_2 (the vowels a, o, i are, in fact, among the top-5 most likely in T8.1.). The most likely transitions from S_3 (in decreasing order) are S_1, S_3 , and S_2 , which seem reasonable as before.

Second Letter. The second letters will be those that are likely to follow the first letters, which are from S_3, S_1 , and S_2 . S_3 transitions to S_1 (to produce *th, tr, at, sh, etc.*), S_3 (to produce *ta, tr, na, to, no, etc.*), and (though very unlikely) S_2 (to produce *te, to, ti, ta, no, ni, etc.*). S_1 transitions mainly to S_2 (to produce *te, to, ti, he, ho, hi, se, so, si, etc.*). S_2 transitions to S_3 (to produce *et, en, ea, es, ot, on, oa, it, at, etc.*), S_1 (to produce *et, es, er, ed, ot, or, ad, etc.*), and S_2 (to produce *ee, ei, ea, oa, oy, etc.*). Such combinations are familiar beginnings of words in English. Furthermore, as shown in T8.2, the most likely second letters are *o, h, e, n, a, i, r*, which matches well with our model result.

Last Letter. The last letter in a word will be those that occur before $\#$, which mean those letters in states transitioning to S_2 and S_3 . S_1 is very likely to transition to S_2 , which makes *t, h, s, r, d, n* likely last-letters; T9.-1 asserts that among non-vowels *s, d, n, t, y, r* are most likely, which agrees reasonably well. S_2 also can transition to S_2 (and S_3), which makes *e, o, i* likely last-letters, which is similar to T9.-1. S_3 can also transition to S_3 , which would make *t, n, a, s, c* likely last-letters; T9.-1 asserts

that at least *s, n, t* are very likely in this position.

Second-to-Last Letter. The second-to-last letter in a word will be those that occur before the last letter; which mean those letters in states transitioning to S_1, S_2 , and S_3 . S_3 likely transitions to S_1 (to produce *th, ts, nt, ns, at, ah, as, ar, etc.*) and S_2 likely transitions to S_1 (to produce *et, es, er, ot, is, etc.*). S_1 is very likely to transition to S_2 (to produce *te, to, ho, se, so, re, ro, etc.*) and S_2 can transition to S_2 (to produce *ee, eo, ea, ie, etc.*). S_2 is likely to transition to S_3 (to produce *et, ot, en, on, as, etc.*) and S_3 can transition to S_3 (to produce *nt, at, ns, etc.*). Most of these are familiar endings to common English words. Furthermore, as shown in T9.-2, the most likely second-to-last letters are *e, o, n, a, h, i, t, r*, which matches well with our model result.

B Final		
1	2	3
t	#	#
h	e	t
s	o	n
r	i	a
d	a	s
n	u	c
l	y	r
m	h	o
c	p	l
f	z	i

Table 2: **Three Hidden States B Truncated.** Here we show the ten most likely symbols for each state, arranged in non-increasing order of probability.

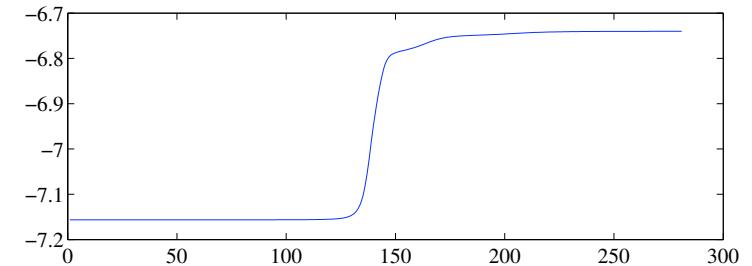


Figure 4: **Three Hidden States Convergence.** The log-likelihood plot is shown (where base 2 was used), which clearly levels off after 282 iterations, which is the time at which all model parameters changed less than 1e-4.

2.3 Four Hidden States

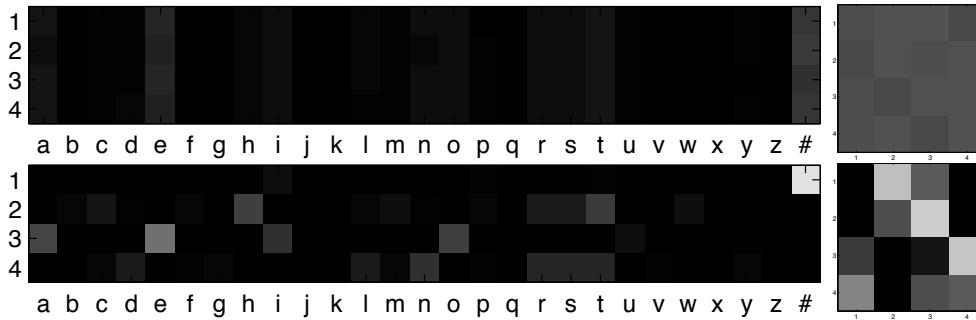


Figure 5: **Four Hidden States.** Above: B and A initial. Below: B and A final.

As Figure 6 shows, for four hidden states, it took 253 iterations for the model parameters to converge. As shown in Figure 5 and further emphasized by Table 3, *B* asserts that S_1 is dominated by $\#$; S_3 is dominated by vowels; S_2 and S_4 consist mainly of consonants.

Combining the results from *A* and *B*, we now examine some of the results in more detail and obtain the following observations:

First Letter. The first letters will be those that are likely to follow $\#$ (in S_1), which means primarily those letters in S_2 (h, t, s, r, c) and S_3 (e, a, o, i, u). T8.1 asserts that the most likely first letters are t, a, o, i, s, w, c , which agrees fairly well with our model’s result.

Second Letter. The second letters will be those that are likely to follow the first letters, which are from S_2 and S_3 . S_2 is likely to transition to S_3 (to produce $he, ha, ho, hi, te, ta, to, se, sa$, etc.) and S_2 (to produce th, st, sh, sc , etc.). S_3 is likely to transition to S_4 (to produce $en, es, er, an, as, ar, on$, etc.) and S_1 (to produce $ei, et, ep, at, ap, ac, ot$, etc.). Such combinations are familiar beginnings of words in English. Furthermore, as shown in T8.2, the most likely second letters are o, h, e, n, a, i, r , which matches well with our model result.

Last Letter. The last letter in a word will be those that occur before $\#$ (in S_1), which means primarily those letters in S_4 (n, s, r, t, d etc.) and S_3 (e, a, o, i , etc.). T9.-1 asserts that the most likely last letters are e, s, d, n, t, y, r , which agrees fairly well with our model’s result.

Second-to-Last Letter. The second-to-last letter in a word will be those that occur before the last letter (in S_4 and S_3). S_3 likely transitions to S_4 (to produce $en, es, er, an, as, ar, at, on, or$, etc.) and S_4 transitions to S_4 (to produce ns, nt, rs, ts , etc.). S_2 likely transitions to S_3 (to produce he, te, se, re , etc.), S_1 likely transitions to S_3 (to produce ie, te, to, pe, pa , etc.), and S_4 transitions to S_3 (to produce $ne, na, no, se, sa, re, ro, te$, etc.). Such combinations are familiar endings of words in English. Furthermore, as shown in T9.-2, the most likely second-to-last letters are

e, o, n, a, h, i, t, r , which matches well with our model result.

1	2	3	4
#	h	e	n
i	t	a	s
t	s	o	r
p	r	i	t
c	c	u	d
u	w	y	l
b	m	h	m
x	l	x	c
v	p	#	y
z	b	b	g

Table 3: **Four Hidden States B Truncated.** Here we show the ten most likely symbols for each state, arranged in non-increasing order of probability.

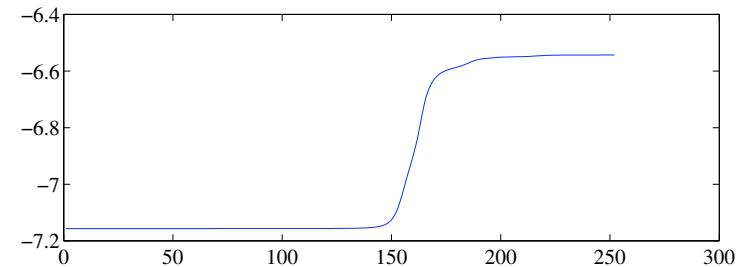


Figure 6: **Four Hidden States Convergence.** The log-likelihood plot is shown (where base 2 was used), which clearly levels off after 253 iterations, which is the time at which all model parameters changed less than 1e-4.

2.4 Five Hidden States

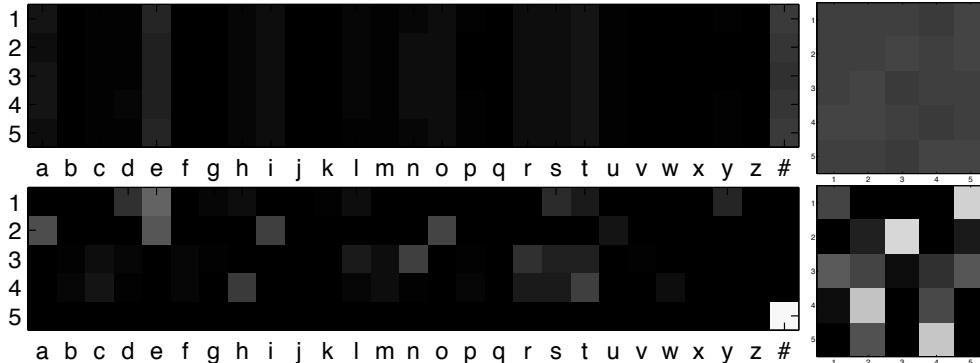


Figure 7: **Five Hidden States.** Above: B and A initial. Below: B and A final.

As Figure 8 shows, for five hidden states, it took 297 iterations for the model parameters to converge. As shown in Figure 7 and further emphasized by Table 4, B asserts that S_5 is dominated by $\#$; S_2 is dominated by vowels; S_1 appears to be dominated by likely last-letters (as shown in T9.-1); S_3 and S_4 consist mainly of consonants.

Combining the results from A and B , we now examine some of the results in more detail and obtain the following observations:

First Letter. The first letters will be those that are likely to follow $\#$ (in S_5), which are S_4 (t, h, s, r, c) and S_2 (e, a, o, i, u). Considering T8.1 asserts that the most likely first letters of words are t, a, o, i, s , the model does fairly well with five hidden states.

Second Letter. The second letters will be those that are likely to follow the first letters, which are from S_4 and S_2 . S_4 is likely to transition to S_2 (to produce $te, ta, to, ti, he, ha, ho, se, sa, so$, etc.) and S_4 (to produce th, tr, st, sc, wh , etc.). Such combinations are familiar beginnings of words in English. Furthermore, as shown in T8.2, the most likely second letters are o, h, e, n, a, i, r , which matches well with our model result.

Last Letter. The last letter in a word will be those that occur before $\#$ (in S_5), which means primarily those letters in S_1 (e, d, s, y, t), S_3 (n, r, s, t, l), and S_2 (e, a, o, i, u). T9.-1 asserts that the most likely last letters are e, s, d, n, t, y, r , which agrees well with our model's result.

Second-to-Last Letter. The second-to-last letter in a word will be those that occur before the last letter (in S_1, S_3 , and S_2). S_3 likely transitions to S_1 (to produce ne, nd, re, rd , etc.) and S_1 likely transitions to S_1 (to produce ee, ed, ds, dy , etc.). S_2 likely transitions to S_3 (to produce en, an, or, it , etc.) and S_3 can transition to S_3 (to produce rn, ts, st , etc.). S_4 likely transitions to S_2 (to produce te, th, he, ho, hi , etc.). Such combinations are familiar endings of words in English. Furthermore, as shown in T9.-2, the most likely second-to-last letters are e, o, n, a, h, i, t, r , which

matches well with our model result; better than with less hidden states.

B Final				
1	2	3	4	5
e	e	n	t	#
d	a	r	h	u
s	o	s	s	c
y	i	t	r	p
t	u	l	c	m
h	h	c	w	s
l	y	m	m	t
g	#	d	p	z
k	x	f	l	b
#	b	p	b	a

Table 4: **Five Hidden States B Truncated.** Here we show the ten most likely symbols for each state, arranged in non-increasing order of probability.

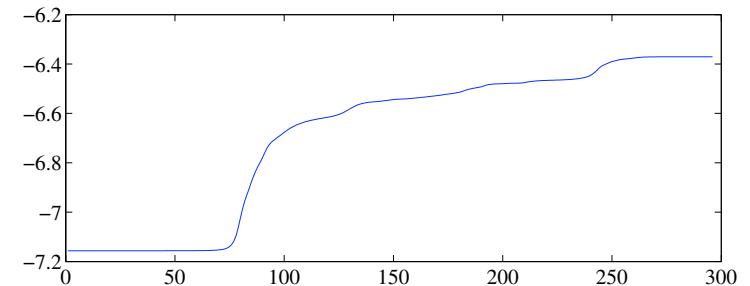


Figure 8: **Five Hidden States Convergence.** The log-likelihood plot is shown (where base 2 was used), which clearly levels off after 297 iterations, which is the time at which all model parameters changed less than 1e-4.

2.5 Six Hidden States

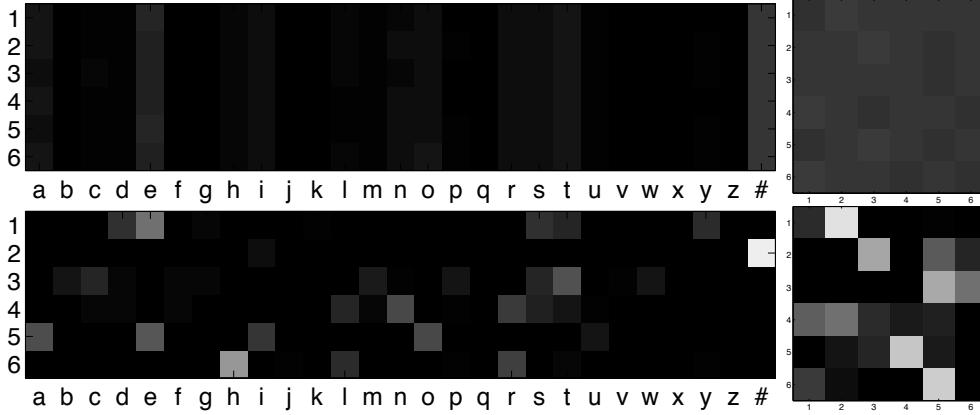


Figure 9: **Six Hidden States.** Above: B and A initial. Below: B and A final.

As Figure 10 shows, for six hidden states, it took 286 iterations for the model parameters to converge. As shown in Figure 9 and further emphasized by Table 5, B asserts that S_2 is dominated by $\#$; S_5 is dominated by vowels; S_1 appears to be dominated by likely last-letters (as shown in T9.-1); S_3 , S_4 , and S_6 consist mainly of consonants.

Combining the results from A and B , we now examine some of the results in more detail and obtain the following observations:

First Letter. The first letters will be those that are likely to follow $\#$ (in S_2), which are S_3 (t, c, s, m, w) and S_5 (e, a, o, i, u), and S_6 (h, r, l, t, y). Considering T8.1 asserts that the most likely first letters of words are t, a, o, i, s, w, c , the model does quite well with six hidden states.

Second Letter. The second letters will be those that are likely to follow the first letters, which are from S_3 , S_5 , and S_6 . S_3 is likely to transition to S_5 (to produce $te, ta, to, ti, ce, ca, ho, se, sa, so$, etc.) and S_6 (to produce th, tr, ch, cr, cl, sh , etc.). S_5 likely transitions to S_4 (to produce en, an, on, in , etc.) Such combinations are familiar beginnings of words in English. Furthermore, as shown in T8.2, the most likely second letters are o, h, e, n, a, i, r , which matches well with our model result.

Last Letter. The last letter in a word will be those that occur before $\#$ (in S_2), which means primarily those letters in S_1 (e, d, s, y, t), and S_4 (n, r, l, s, t). T9.-1 asserts that the most likely last letters are e, s, d, n, t, y, r , which agrees well with our model's result.

Second-to-Last Letter. The second-to-last letter in a word will be those that occur before the last letter (in S_1 and S_4). S_4 transitions to S_1 (to produce $ne, nd, ns, re, rd, rs, le, ld, ls$, etc.), S_6 transitions to S_1 (to produce $he, re, rd, rs, le, ld, ls$, etc.), and S_1 transitions to S_1 (to produce ee, ed, es, ds, st , etc.). S_5 likely transitions to S_4 (to produce $en, er, el, ar, al, on, or, in, is$, etc.) and S_4 can transition to S_4 (to produce ns, rn, rl, rs, st, ts , etc.). Such combinations are familiar endings of words

in English. Furthermore, as shown in T9.-2, the most likely second-to-last letters are e, o, n, a, h, i, t, r , which matches well with our model result.

B Final					
1	2	3	4	5	6
e	#	t	n	e	h
d	i	c	r	a	r
s	u	s	l	o	l
y	y	m	s	i	t
t	m	w	t	u	y
g	p	p	d	c	p
k	s	b	c	y	j
#	a	f	m	k	m
a	b	g	f	b	w
b	c	d	p	d	k

Table 5: **Six Hidden States B Truncated.** Here we show the ten most likely symbols for each state, arranged in non-increasing order of probability.

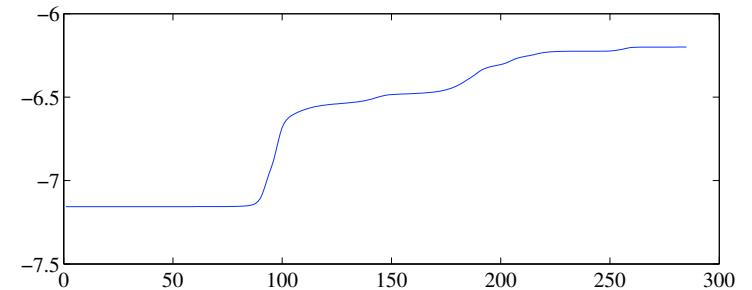


Figure 10: **Six Hidden States Convergence.** The log-likelihood plot is shown (where base 2 was used), which clearly levels off after 286 iterations, which is the time at which all model parameters changed less than $1e-4$.

2.6 Seven Hidden States



Figure 11: **Seven Hidden States.** Above: B and A initial. Below: B and A final.

As Figure 12 shows, for seven hidden states, it took 299 iterations for the model parameters to converge. As shown in Figure 11 and further emphasized by Table 6, *B* asserts that S_1 clearly is dominated by vowels with their probability in the same order (e, a, o, i, u) as T7. S_2 is dominated by $\#$; S_5 looks very similar to last-letters, as found in T9.-1; the other states primarily contain consonants.

Combining the results from *A* and *B*, we now examine some of the results in more detail and obtain the following observations:

First Letter. The first letters will be those that are likely to follow $\#$, which dominates S_2 . The most likely transitions from S_2 (in decreasing order) are S_6 (with m, t, s, c being most likely), S_3 (with t, s, c, p, w being most likely), and S_1 (with e, a, o, i being most likely). Considering T8.1 asserts that the most likely first letters of words are t, a, o, i, s, w, c , the model does quite well with seven hidden states.

Second Letter. The second letters will be those that are likely to follow the first letters, which come from S_6, S_3 , and S_1 . S_6 likely transitions to S_1 (to produce me, ma, to, ti , etc.). S_3 likely transitions to S_7 (th, tr, so , etc.). S_1 likely transitions to S_4 (to produce en, er, as , etc.). Such combinations are familiar beginnings of words in English. Furthermore, as shown in T8.2, the most likely second letters are o, h, e, n, a, i, r , which matches well with our model result.

Last Letter. The last letter in a word will be those that occur before $\#$, which come from (primarily) S_5, S_4 , and S_7 . S_5 consists of e, d, s, y, t , etc., which matches very closely to the e, s, d, n, t, y of T9.-1; though, clearly, n is not accounted for by S_5 . However, S_4 is dominated by n ; it also has r, s, l, t , etc., which generally agrees with T9.-1. S_7 consists of h, r, l, o , etc. which all end up lower in probability in the table; which makes the model reasonable considering the transition from S_7 to S_2 is unlikely.

Second-to-Last Letter. The second-to-last letter in a word will be those that occur before the last letter (contained in S_5, S_4 , and S_7). S_4, S_7 , and S_5 (dominated by n, r, s, l, t, h, e) transition to S_5 (to produce combinations like ne, nd, re, rd). S_1 and S_4 (dominated by vowels and n, r, s, l, t) transition to S_4 (to produce combinations like $en, er, es, an, ar, ns, rs, ls$). S_3 and S_7 (dominated by t, s, c, h, r, l) transition to S_7 (to produce combinations like $th, sh, etc.$). Such combinations are familiar endings of words in English. Furthermore, as shown in T9.-2, the most likely second-to-last letters are e, o, n, a, h, i, t, r , which matches well with our model result.

B Final						
1	2	3	4	5	6	7
e	#	t	n	e	m	h
a	I	s	r	d	t	r
o	u	c	s	s	s	l
I	y	p	l	y	c	o
u	a	w	t	t	h	t
y	z	g	d	g	r	e
c	x	b	c	l	w	u
k	g	f	f	k	d	I
p	o	q	m	#	b	p
z	m	d	p	m	f	c

Table 6: **Seven Hidden States B Truncated.** Here we show the ten most likely symbols for each state, arranged in non-increasing order of probability.

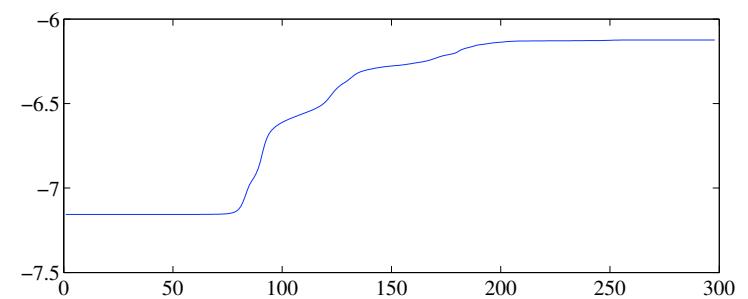


Figure 12: **Seven Hidden States Convergence.** The log-likelihood plot is shown (where base 2 was used), which clearly levels off after 299 iterations, which is the time at which all model parameters changed less than $1e-4$.

3 New Results: Models to Symbols

In this section, we show the results of using the obtained models to generate text. We show some of the resulting words for using each of the models obtained for the different number of hidden states (2 to 7). Keep in mind, we do include some personal names, common words (that may be less than proper and in some cases actually offensive), and a few contractions (but without the punctuation, as it was not available in the symbol set or original observation sequence). Also, words used commonly in English that are originally from other languages (like German, Greek, Hebrew, and Latin), words from more specific domains like mathematics/science, and slightly outdated words are included when recognized, as well.

Considering the original observation sequence had length 17,340, the generated text has the same length. The results improve with more hidden states, as shown in Figure 13 and Figure 14; of particular interest is the jump in generated English words between 3 hidden states (with 110 English words, which means 4.2389% correct) and 4 hidden states (with 360 English words, which means 12.3924% correct). This result matches well with examining the final A and B matrices from the previous section; clearly it was not until 4 hidden states when the model was able to partition the symbols such that #, vowels, and consonants (occupying two such states) each had their own distinct state to dominate. However, the results are still not stunning. The results are discussed more in Sections 4 and 5. We now examine the generated English words for each number of hidden states; some more interesting words and/or sequences of words have been highlighted in yellow.

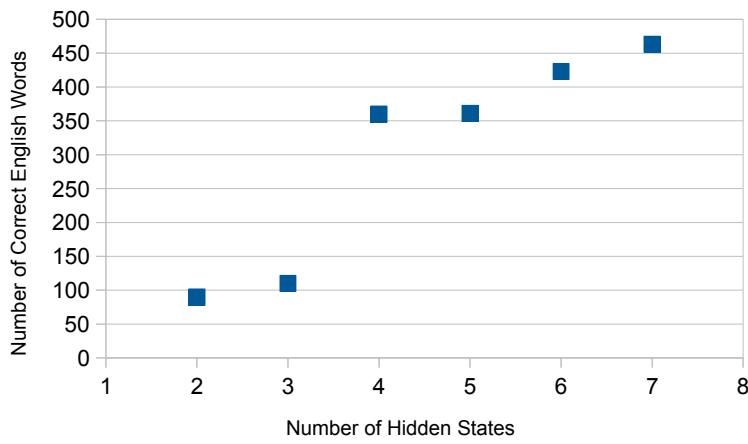


Figure 13: **Correctly Generated English Words (Raw).** The plot shows the number of correctly generated English words as a function of the number of hidden states.

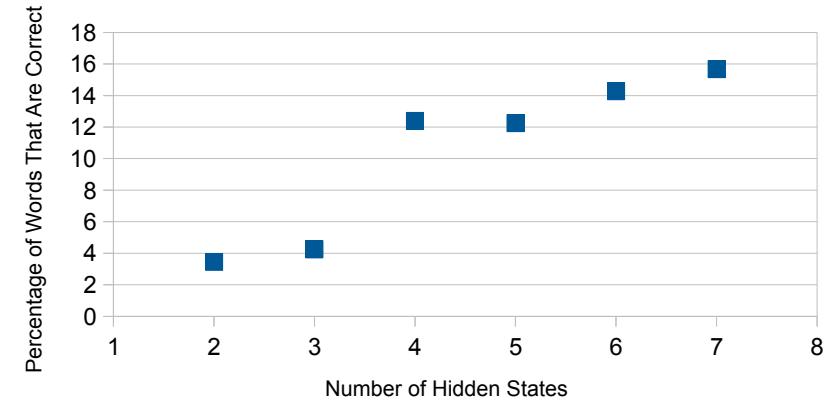


Figure 14: **Correctly Generated English Words (%).** The plot shows the percentage of correctly generated English words as a function of the number of hidden states.

3.1 2 Hidden States

The following is a list of the 90 English words that were generated (out of the total 2,611), in the order they appeared in the document:

pots, at, has, low, son, toy, cad, yo, an, hem, ho, hat, dies, some, arts, gay, nay, he, pi, at, set, ben, rat, hut, tin, tit, he, gin, ton, or, rat, rat, lisa, ran, hit, me, us, us, sine, den, dog, me, sat, is, pam, sit, hi, om, gem, it, nil, gap, in, ted, go, shaw, rob, her, let, id, tat, he, an, go, set, ted, hi, ho, rear, an, he, to, jet, me, mew, rag, mew, to, rent, scan, hen, get, roth, dime, ban, is, poo, ad, et, hi, a

3.2 3 Hidden States

The following is a list of the 110 English words that were generated (out of the total 2,595), in the order they appeared in the document:

as, i, i, run, ran, cant, gem, ted, om, if, sam, her, ether, dew, hone, om, hi, bad, he, pa, me, her, is, or, or, mo, lab, ran, ha, ipod, irs, am, at, per, den, loft, me, ram, me, rosy, chi, ad, spot, or, awry, as, ad, if, han, on, as, on, ole, ab, neo, mo, sag, it, as, id, eat, so, get, sam, i, pea, if, hoe, heel, an, me, et, vat, men, et, at, he, ho, cd, do, rim, ton, dot, had, has, do, no, rod, ate, few, tit, so, has, him, hi, cut, or, the, sale, man, on, ho, cd, hem, hot, saw, law, rat, item, we

3.3 4 Hidden States

The following is a list of the 360 English words that were generated (out of the total 2,905), in the order they appeared in the document:

a, we, hi, yes, lo, hen, hes, mens, ted, hey, **tenet**, an, it, rid, tent, in, he, he, i, set, bead, **hey, rad, hen**, as, is, et, he, **ole, hen, i, i, hi, lo, ram, an, hit, fad, honed**, yo, us, sal, chi, rot, ho, him, **fat, gem**, a, ron, ten, a, wed, ant, et, me, dad, he, lo, he, ton, as, **he, hobo, id, id, am, tan, hit, hi, to, rho, ulna, set**, teen, act, to, or, so, her, hes, we, inn, lo, of, as, we, et, hes, pad, son, so, lit, or, ho, hos, in, sad, won, am, as, an, a, et, whir, in, pod, me, hog, a, on, sin, han, at, on ok, tar, **toy, rust, riser**, then, got, hear, pipe, ab, me, to, err, in, ho, herd, i, **ad, sat, rusted**, a, to, he, tin, han, ho, den, ted, pat, so, pod, han, cum, ho, dan, peso, tad, hoe, mow, set, his, **ban, soy**, has, pa, as, a, in, he, yo, hos, wad, ad, tad, i, at, hag, hey, hot, ago, a, sal, sam, hes, he, art, him, me, bet, par, be, a, had, at, her, ray, far, tau, all, a, at, mom, lot, or, teen, in, tote, bat, to, pa, i, hi, he, hes, call, fit, ha, ha, i, rat, as, cot, be, a, go, ton, ad, hi, i, **tales**, he, i, ho, eat, he, is, as, ho, ho, ye, mort, elon, hew, et, on, his, mono, any, we, rile, a, tat, who, as, i, of, as, her, et, lens, **she, ipal, tan, lies**, an, et, ton, ate, ho, he, mob, ho, om, do, a, it, to, an, **usa**, he, tin, i, a, ad, set, **lastwan**, pair, **lol, gel**, he, is, ma, ten, an, was, he, at, tart, ran, is, **ban, hen, lab, a, era, pager**, save, it, do, you, i, red, had, we, cat, so, a, tin, be, i, a, ten, if, tans, to, a, bun, a, i, he, nut, i, ho, or, tin, et, **top, ten**, or, me, ho, sam, i, as, ann, sod, ben, he, hod, pin, in, as, ma, hi, me, sit, ben, on, ho, ten, am, yo, hi, hen

3.4 5 Hidden States

The following is a list of the 361 English words that were generated (out of the total 2,945), in the order they appeared in the document:

dear, rub, he, **pap, hire, devil, mom, top, dad, in, pi, try, he, so, et, jen, mine, at, as, tar, steel, in, i, on, pi, he, hem, my, rap, ann, son, are, per, cowy, are, figs, hid, if, pep, ten, hod, enter, at, bon, bun, tare, ten, ted, hot, on, her, is, ton, car, abe, pang, con, do, adele, old, ab, taft, put, hale, end, on, ab, bet, sent, it, hat, a, tit, far, rite, pen, debt, he, on, ron, yo, be, pi, an, ben, man, sin, seger, yes, hen, cat, ate, hi, cot, it, lo, tale, me, do, tube, toke, cone, per, lot, or, fib, ant, it, van, so, a, todd, ease, hi, to, one, venn, hem, gat, erin, pals, sere, tide, is, i, ale, is, hat, tiny, nosy, wet, tan, bins, ran, my, turd, is, tin, or, ore, hens, rot, end, tic, to, wed, thaïs, to, on, dare, vary, hard, he, is, cite, tit, an, ben, i, on, tap, poor, i, he, i, lo, sag, sip, hod, or, it, tan, of, end, an, are, id, man, tide, tan, be, at, hose, ton, tug, we, be, to, hop, ted, rare, **teas**, taut, lisa, **her, gods**, at, cab, ab, rot, he, as, mo, to, as, matte, tau, ep, alt, i, to, on, hen, ring, torses, hot, tars, hind, **con, in, ante, jar**, om, men, hans, ret, hi, **trope**, poms, be, bas, rep, ire, rig, lit, al, he, or, i, hast, toby, be, on, mo, mean, ides, fad, ho, is, bits, mit, tor, gem, to, he, word, hand, as, ho, sat, per, two, ho, sad, be, alt, come, he, mite, merl, care, ep, won, sit, ode, mit, hes, pen, van, tie, act, be, we, let, who, id, rare, rot, see, pa, pal, me, in, see, rob, hes, hem, win, mu, tan, cad, sir, a, sot, tor, con, lol, tum, reel, ton, **man, alas, ewe, rat, he, tend, con, am, to, war, his, celt, ban, tsar**, hi, hip, her, mine, poorer, tog, tone, hes, ale, won, ere, ten, pined, are, or, ton, an, ret, don, par, to, he, hat, par, **bed, hare, hang, on, page, sot, ho, olde, add, bit, her, par, his****

3.5 6 Hidden States

The following is a list of the 423 English words that were generated (out of the total 2,962), in the order they appeared in the document:

unto, tad, ten, it, son, name, tan, **army**, the, wend, hen, tom, woe, in, the, bun, we, thin, **lend, the, aid, chits**, the, tee, **buy, hi, art, go, in, a, hex**, these, the, see, mod, wore, dams, man, **motet**, rot, fore, **incus**, a, tame, tar, parr, a, bel, it, on, **cap, guns**, pans, am, and, mere, an, her, tide, i, tar, he, he, the, a, cor, seat, hole, wad, cone, i, phil, tar, an, sin, lee, rows, on, ant, me, tab, an, **host, add, cod**, an, hes, pore, tore, tao, **so, base**, she, stent, at, toe, mit, the, she, then, ere, ho, i, set, won, to, else, the, an, hes, rices, ran, shod, **band**, at, an, to, hey, a, sing, add, ale, sob, pus, gas, bis, **ad, on, fed, pen**, i, wen, pen, pen, she, in, **taylor**, son, tin, lo, ate, et, hips, sole, bon, case, war, **pod**, she, ox, or, titer, gens, an, puny, tare, gel, tin, tin, the, won, **he, mops**, prop, i, so, bin, he, lo, **toy**, a, mit, **tan, vast, shin**, one, **a, mad, sans**, a, to, came, tan, ole, end, tat, on, son, ma, tic, **tea, bar**, et, use, **thor**, an, veld, as, sip, is, had, me, a, tan, hide, son, **home**, pot, ye, pods, ant, tim, cor, ore, char, i, tare, sac, eel, tent, et, tent, pa, tau, on, **ate, ran**, he, fan, can, om, **be, an, ode, stan**, bon, rep, ape, rune, bis, bore, fir, ab, he, **rye, pen, thin, fame**, one, mace, tone, pill, hops, sod, pen, ace, ten, **can, cite, pa**, in, or, on, rid, bast, on, mo, avon, he, he, us, byes, **hal, vic, or, bard**, cart, tors, or, pars, tile, not, man, a, i, wire, cot, one, mont, i, id, oar, for, he, on, pit, or, for, pop, or, hex, id, a, **tips, tire, tar**, us, par, ton, as, as, sat, a, vise, **no, tin**, pore, ho, bass, an, in, a, sal, her, same, win, ere, is, cad, told, cot, sot, fir, vin, pa, **van, car**, thom, in, had, an, on, of, gal, an, ben, char, the, barry, ad, sit, when, ab, or, tin, an, ben, pine, tot, save, pock, a, dye, **she, fry, ten**, who, sec, err, **shine, ant, mine**, he, pox, on, **gold**, is, is, to, han, a, per, a, tics, i, hap, us, cep, whet, tron, pole, mar, **ad, ink**, has, is, et, hen, tees, less, cay, wes, shin, han, hong, tan, tit, mild, her, sir, he, chin, ho, **dire, bile, case**, hod, cant, ok, cad, han, soar, shy

3.6 7 Hidden States

The following is a list of the 463 English words that were generated (out of the total 2,953), in the order they appeared in the document:

be, on, mom, hap, ere, tar, ere, end, vise, bed, car, pal, hal, mate, meld, an, toil, the, yore, thor, tau, cry, on, on, cd, bar, sean, mac, dot, in, war, ask, an, toe, the, **for, a, dome**, ban, et, vein, ill, if, **amen, wet, us, vis, fire**, an, at, on, thy, ton, rick, **halt, i, dane, shale, the, ran, mo, sots, et, of, cans, any, san, as, ire, shy, the, ale, rot, pat, an, in, me, an, a, amen, whore, wed, chic, hal, am, dane, dan, men, sate, the, chine, an, an, ties, it, fin, pins, rons, an, bart, ire, mole, vans, an, these, mane, mom, lat, shot, toot, thy, sea, is, sud, ben, cut, end, us, on, ton, ere, stan, tens, did, fast, hiv, bon, den, dimer, sift, **we, her, cog, int, mols, shear**, on, con, for, shin, man, fore, if, at, fete, chin, the, ere, yet, ted, sass, dane, tip, ice, pen, ma, per, ere, at, ward, cont, ben, rake, vent, none, ire, tire, tot, any, on, mess, i, pond, av, thane, me, ode, thy, is, caret, vale, **mule, hen, thy, she, cot, the, the, captor**, von, tan, so, wow, den, me, male, on, on, is, she, one, went, ten, at, ere, din, pal, and, the, a, try, man, is, seas, far, or, act, lit, the, cue, rob, pert, ore, on, add, tut, fog, **con, boss**, mo, thy, abel, me,**

doc, shed, rid, a, wens, wen, con, sear, vise, **lend, any, tens, cheer, icy, mat, rudy,**
 pi, pen, om, vale, yes, viste, he, wast, tin, tar, she, tess, fen, mote, as, rink, ewer,
 tug, an, as, cor, **wine**, vane, bas, tap, ton, hi, bar, so, gams, om, on, shes, i, sot, or,
 tor, an, or, **lo, sane, in, me**, sosa, mar, bee, tirol, there, tags, the, pep, cor, fame, a,
 or, fines, tim, sec, wen, ban, i, inch, **shod, lore**, there, ton, toon, pen, gat, the, me,
 on, on, to, van, when, us, are, chum, dory, den, hen, i, rod, **son, is, fat**, tot, fen, tart,
 tens, he, are, dos, in, in, me, wen, are, why, is, in, use, ton, **soft, bon, the, roll**, et,
 sine, ass, be, bin, **toe, ink**, ho, tron, et, in, soon, an, sod, **wet, fan**, yom, cot, nan,
 int, hunt, cunt, sit, om, lo, at, men, as, rot, ben, **me, get, gins**, han, to, **i, am, of, rem**,
 so, lard, molds, hep, otto, to, nan, far, ad, **pet, pan**, one, i, vert, rest, bud, at,
 nose, con, tee, hen, go, a, as, **the, dose**, sod, ron, **yes, art, gran**, the, **dat, tan, cane**,
 bon, dad, hep, the, **if, she, war**, cot, eld, one, bart, wave, the, cam, tun, vice, than,
 men, core, ran, cols, eld, that, ben, rase, ad, is, met, the, fan, mu, fore

4 Discussion

It is not clear, *a priori*, exactly how well a hidden Markov model can perform in terms of capturing linguistic structure, particularly with regard to being able to generate English text. There was definite improvement observed but at 15.68% correct English words at 7 hidden states, it still performed quite poorly. Though, as one could see by reading the full text provided in Appendix D, the generated text does read more like real English. However, the error rate for actually generating real English words remains quite high. This result seems consistent with Shannon’s series of approximations to English in which, after producing stochastic approximations up to the third-order (tri-gram), he decided to focus on word-level approximations to generate more English-like text (see p. 43 of Shannon [5]). Perhaps we do not have to concede in such a way; though, with a desire to generate better English text, one may want to investigate a number of modifications.

It would be instructive to perform the computations for up to 12 hidden states (or more) to see how this affects the model’s generative performance. Also, it would be interesting to see how much better it could perform by providing better input text— perhaps more “proper” text that does not consist of contractions, slang, etc. Also, trying different symbol sets (like using various sets of n -grams), could provide insight. Furthermore, using a *hierarchy* of HMMs would be fascinating. For instance, the lowest HMM could be used to learn highly probable 1 and 2-grams, the next highest HMM could use the learned 1 and 2-grams as its symbol set to learn higher-order n -grams, etc. Following this procedure might lead to a set of models that could generate more English-like (and maybe even English) words. Also, continuing such a hierarchy may even lead to discovering linguistic structure at the word-level. Furthermore, conducting the experiment for text from different eras of English to see how the statistics compare could possibly bring insight to questions like: (1) how does the evolution of a language show up in its statistics? (2) Are there conservation rules? (3) Is there structural drift that can be detected?

5 Conclusion

The HMM is clearly a powerful model. The results seemed to match the original experiments fairly well. More than pointing out the usefulness of a single HMM at discovering low-level linguistic structure, the experiments have simply emphasized the significance of the model for discovering and representing structure in more general complex systems. The author would like to investigate the usefulness of a single HMM and a hierarchy of HMMs in discovering hierarchical structure in complex systems. Of particular interest is the process of letting one HMM discover the symbol set to be used by the HMM in a level higher in the hierarchy. Also, having an HMM higher in the hierarchy somehow constrain the model learning or the transitions made by an HMM lower in the hierarchy would be fascinating. The author plans on investigating a number of these issues.

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Appendix A: Ground Truth

letter	%
e	12.49
t	9.28
a	8.04
o	7.64
i	7.57
n	7.23
s	6.51
r	6.28
h	5.05
l	4.07
d	3.82
c	3.34
u	2.73
m	2.51
f	2.40
p	2.14
g	1.87
w	1.68
y	1.66
b	1.48
v	1.05
k	0.54
x	0.23
j	0.16
q	0.12
z	0.09

Table 7: **Letter Frequency.** The frequency of letters is provided in decreasing order [3].

1	2	3	4	5	6	7
T 15.978	O 14.978	E 17.722	E 15.898	E 17.574	E 13.635	E 14.689
A 11.682	H 14.449	R 9.072	T 10.526	R 10.501	N 10.562	T 10.669
O 7.631	E 12.499	T 7.798	I 7.657	I 9.394	I 9.333	S 10.126
I 7.294	N 10.286	A 7.336	N 6.563	T 7.798	R 9.301	I 9.94
S 6.686	A 9.849	D 6.511	S 6.359	S 6.833	T 8.746	N 7.954
W 5.497	I 7.231	S 6.19	L 6.101	N 6.536	S 8.572	A 7.402
C 5.238	R 5.891	O 5.97	R 5.915	L 6.035	A 6.467	R 5.384
B 4.434	F 5.038	N 5.684	A 4.916	O 5.603	D 5.878	L 5.117
P 4.319	U 4.134	I 5.208	O 4.528	A 5.481	L 4.214	D 4.56
H 4.2	T 3.141	I 4.407	H 4.047	D 3.674	C 3.992	O 4.344
F 4.027	S 2.847	M 3.589	C 3.902	H 3.426	O 3.044	G 3.867
M 3.826	L 2.279	C 3.428	D 3.856	U 3.361	G 2.551	Y 3.1
D 3.174	Y 1.211	U 3.101	U 3.581	C 3.339	M 2.233	C 3.099
R 2.826	P 1.152	P 2.348	M 3.406	G 2.471	Y 2.095	M 2.418
E 2.799	C 0.948	V 2.177	P 2.64	M 1.698	H 2.003	U 2.335
L 2.415	M 0.836	G 1.743	G 1.831	Y 1.554	U 1.942	H 1.477
N 2.284	X 0.703	F 1.464	Y 1.816	P 1.248	V 1.132	P 1.037
G 1.642	V 0.58	Y 1.297	K 1.708	K 0.9	P 1.033	B 0.701
U 1.183	D 0.536	W 1.236	V 1.199	V 0.842	F 1.018	F 0.534
V 0.824	B 0.519	B 0.873	W 1.107	B 0.571	B 0.916	V 0.521
Y 0.763	W 0.419	J 0.817	F 1.088	F 0.561	W 0.759	Z 0.266
J 0.511	G 0.295	H 0.741	B 0.929	W 0.392	K 0.211	K 0.172
K 0.456	Q 0.098	K 0.617	J 0.147	Z 0.11	X 0.128	W 0.114
Q 0.222	K 0.063	X 0.313	Q 0.116	X 0.063	Q 0.125	X 0.105
X 0.045	Z 0.01	Q 0.15	Z 0.095	Q 0.027	Z 0.106	Q 0.064
Z 0.045	J 0.009	Z 0.085	X 0.067	J 0.006	J 0.005	J 0.004

Table 8: **Letter Frequency** $\{1, \dots, 7\}$. The frequency of letters is provided in decreasing order. The first column, labeled with a ‘1’, shows the percentage of the time that a given letter was a word-starting letter; thus, ‘t’ was the first letter of a word 15.978% of the time, while ‘o’ was the first letter of a word 7.631% of the time. Similarly, the second column, labeled with a ‘2’, shows the percentage of the time that a given letter was the second letter in a word; thus, ‘o’ was the second letter of a word 14.978% of the time, while ‘r’ was the second letter of a word 5.891% of the time. The other columns show such information for up to the seventh letter in a word. Such information can be used as a reference to evaluate the results of our experiments [3].

-7	-6	-5	-4	-3	-2	-1
E 10.245	E 12.379	A 10.843	T 14.407	I 14.705	E 13.445	E 20.134
R 8.769	R 8.601	E 9.984	I 7.737	T 13.336	O 12.302	S 12.903
A 7.566	A 7.852	T 9.012	A 7.347	A 12.861	N 10.841	D 9.981
C 7.141	I 7.347	I 8.174	O 6.693	E 9.232	A 9.194	N 9.31
O 6.846	S 7.131	R 7.124	R 6.607	O 8.165	H 8.95	T 8.971
I 6.694	O 6.826	O 6.627	E 6.453	H 7.032	I 8.66	Y 6.002
S 6.34	T 6.208	S 6.104	H 6.086	N 5.475	T 7.075	R 5.899
T 5.681	C 5.283	C 5.222	S 5.378	R 4.318	R 5.452	F 4.714
P 5.285	L 4.939	N 5.049	L 5.042	U 4.008	L 5.413	O 4.177
N 5.008	N 4.894	L 4.347	N 4.565	L 2.738	S 3.684	L 3.465
L 4.157	P 4.083	U 4.194	W 4.379	S 2.476	C 3.201	G 2.939
M 3.876	U 4.082	W 3.35	M 4.261	C 1.831	U 2.519	A 2.819
U 3.602	M 3.906	P 3.297	C 3.132	W 1.779	M 1.53	H 2.712
H 2.983	H 2.818	M 2.794	U 2.968	D 1.733	B 1.457	M 1.656
F 2.974	F 2.548	H 2.589	F 2.877	B 1.638	D 1.351	W 0.821
D 2.821	B 2.319	G 2.195	D 2.54	F 1.611	G 1.247	K 0.802
B 2.716	D 2.316	F 2.068	B 2.136	M 1.545	V 1.13	I 0.752
G 1.919	G 1.947	B 1.963	P 2.035	G 1.458	W 0.841	C 0.603
V 1.774	V 1.583	D 1.936	G 1.599	V 1.372	K 0.526	P 0.541
W 1.528	W 1.003	V 1.067	V 1.341	P 1.1	P 0.463	U 0.389
X 0.536	Y 0.478	Y 0.694	K 0.845	Y 0.732	F 0.337	X 0.165
Q 0.424	X 0.436	K 0.379	Y 0.832	K 0.472	Y 0.216	B 0.123
J 0.42	J 0.281	X 0.289	J 0.414	Z 0.147	Z 0.081	V 0.055
Y 0.304	Q 0.28	J 0.278	X 0.125	X 0.105	X 0.07	Z 0.033
K 0.298	K 0.253	Q 0.277	Z 0.124	J 0.086	J 0.013	J 0.022
Z 0.093	Z 0.208	Z 0.054	Q 0.078	Q 0.046	Q 0.004	Q 0.013

Table 9: **Letter Frequency** $\{-7, \dots, -1\}$. The frequency of letters is provided in decreasing order. The last column, labeled with a ‘-1’, shows the percentage of the time that a given letter was a word-ending letter; thus, ‘e’ was the last letter of a word 20.134% of the time, while ‘d’ was the last letter of a word 9.981% of the time. Similarly, the second-to-last column, labeled with a ‘-2’, shows the percentage of the time that a given letter was the second-to-last letter in a word; thus, ‘e’ was the second-to-last letter of a word 13.445% of the time, while ‘h’ was the second letter of a word 8.95% of the time. The other columns show such information for up to the seventh-to-last letter in a word. Such information can be used as a reference to evaluate the results of our experiments [3].

6 Appendix B: Final A and B Matrices

A Final		
	S_1	S_2
S_1	0.27973	0.72027
S_2	0.72731	0.27269

B Final		
1	2	
t 0.1435	# 0.3387	
s 0.1149	e 0.221	
r 0.1073	a 0.1319	
n 0.1024	o 0.1217	
h 0.0887	i 0.1103	
l 0.0639	u 0.0487	
d 0.0622	c 0.0118	
c 0.0498	l 0.0058	
m 0.0483	t 0.004	
p 0.0346	y 0.0036	
y 0.0323	p 0.0014	
w 0.0304	g 0.001	
f 0.0303	k 0.0002	
g 0.0267	z 0	
b 0.0266	h 0	
v 0.0172	s 0	
k 0.009	d 0	
x 0.0048	b 0	
j 0.0032	w 0	
q 0.0013	n 0	
z 0.0013	x 0	
# 0.0011	f 0	
a 0	r 0	
u 0	q 0	
o 0	j 0	
i 0	m 0	
e 0	v 0	

Table 10: **Two Hidden States Results.** Convergence was declared after 176 iterations.

A Final			
	S_1	S_2	S_3
S_1	0.023889	0.97611	0
S_2	0.38908	0.13969	0.47123
S_3	0.78609	0.0022561	0.2116

B Final			
	1	2	3
t	0.12291	# 0.3254	# 0.15569
h	0.12174	e 0.27248	t 0.12628
s	0.11235	o 0.11769	n 0.11605
r	0.11091	i 0.1129	a 0.089554
d	0.08332	a 0.10908	s 0.073921
n	0.066028	u 0.038164	c 0.070055
l	0.064485	y 0.019707	r 0.060263
m	0.060319	h 0.0033366	o 0.054106
c	0.039296	p 0.0010843	l 0.049949
f	0.036531	z 0.00015017	i 0.038698
p	0.029	b 0	u 0.036556
y	0.028433	c 0	p 0.030324
g	0.027865	d 0	b 0.022799
w	0.027756	f 0	w 0.022494
v	0.02436	g 0	g 0.016595
b	0.02219	j 0	m 0.011853
k	0.011873	k 0	f 0.0093371
j	0.0045472	l 0	d 0.0069213
x	0.0021314	m 0	x 0.0069033
q	0.0017864	n 0	k 0.0016477
z	0.0016157	q 0	e 0
#	0.00055466	r 0	h 0
a	0	s 0	j 0
e	0	t 0	q 0
i	0	v 0	v 0
o	0	w 0	y 0
u	0	x 0	z 0

Table 11: **Three Hidden States Results.** Convergence was declared after 176 iterations.

A Final				
	S_1	S_2	S_3	S_4
S_1	0.0044494	0.70153	0.29214	0.0018782
S_2	0.00013568	0.2436	0.75626	0
S_3	0.18936	0.00011754	0.075282	0.73524
S_4	0.44359	0.013761	0.25094	0.29172

	1	2	3	4
#	0.85789	h 0.20515	e 0.36494	n 0.153
i	0.052139	t 0.17768	a 0.21778	s 0.12674
t	0.024632	s 0.095647	o 0.20094	r 0.1204
p	0.01886	r 0.086016	i 0.14811	t 0.11423
c	0.017324	c 0.069206	u 0.051225	d 0.084536
u	0.016823	w 0.063975	y 0.013381	l 0.082524
b	0.010403	m 0.050106	h 0.0030148	m 0.047251
x	0.0011142	l 0.048283	x 0.00031541	c 0.045981
v	0.00032137	p 0.042206	# 0.00027496	y 0.038795
z	0.00030452	b 0.035754	b 0	g 0.035098
m	0.00019065	f 0.034564	c 0	f 0.027814
a	0	d 0.025346	d 0	v 0.02301
d	0	n 0.018649	f 0	p 0.020384
e	0	g 0.015408	g 0	u 0.017466
f	0	y 0.0098996	j 0	h 0.016034
g	0	j 0.0085714	k 0	b 0.014669
h	0	v 0.0073198	l 0	k 0.013056
j	0	k 0.0027683	m 0	w 0.010312
k	0	q 0.002003	n 0	x 0.006728
l	0	z 0.0012507	p 0	z 0.0010814
n	0	# 0.00020507	q 0	q 0.00081677
o	0	a 0	r 0	a 0
q	0	e 0	s 0	e 0
r	0	i 0	t 0	i 0
s	0	o 0	v 0	j 0
w	0	u 0	w 0	o 0
y	0	x 0	z 0	# 0

Table 12: **Four Hidden States Results.** Explain and interpret.

A Final					
	S_1	S_2	S_3	S_4	S_5
S_1	0.21304	0.0078729	0	0	0.77909
S_2	0.012281	0.1083	0.79875	0	0.080673
S_3	0.29668	0.21797	0.058725	0.14388	0.28274
S_4	0.063469	0.70818	0	0.22835	0
S_5	0	0.26848	0	0.73004	0.0014857

B Final					
1	2	3	4	5	
e 0.31686	e 0.27359	n 0.20421	t 0.19535	# 0.969	
d 0.14587	a 0.2382	r 0.15608	h 0.18206	u 0.014689	
s 0.13299	o 0.21978	s 0.10134	s 0.093606	c 0.008176	
y 0.1262	i 0.19926	t 0.10063	r 0.083895	p 0.0059656	
t 0.090826	u 0.065691	l 0.084131	c 0.071888	m 0.0011449	
h 0.058351	h 0.0013301	c 0.061997	w 0.05877	s 0.00037077	
l 0.052775	y 0.0012958	m 0.057411	m 0.05129	t 0.00035849	
g 0.047704	# 0.00043852	d 0.040803	p 0.047406	z 0.00019586	
k 0.024065	x 0.0004116	f 0.034792	l 0.045806	b 0.00010126	
# 0.0043603	b 0	p 0.030637	b 0.036478	a 0	
a 0	c 0	v 0.026713	f 0.034122	d 0	
b 0	d 0	b 0.024727	d 0.027872	e 0	
c 0	f 0	g 0.021983	n 0.01785	f 0	
f 0	g 0	u 0.01528	g 0.017087	g 0	
i 0	j 0	w 0.013121	y 0.012132	h 0	
j 0	k 0	x 0.0098773	v 0.011579	i 0	
m 0	l 0	k 0.0059928	j 0.0077686	j 0	
n 0	m 0	y 0.0059599	k 0.002814	k 0	
o 0	n 0	z 0.0022864	q 0.0019114	l 0	
p 0	p 0	# 0.0010183	z 0.00031718	n 0	
q 0	q 0	q 0.0010142	a 0	o 0	
r 0	r 0	a 0	e 0	q 0	
u 0	s 0	e 0	i 0	r 0	
v 0	t 0	h 0	o 0	v 0	
w 0	v 0	i 0	u 0	w 0	
x 0	w 0	j 0	x 0	x 0	
z 0	z 0	o 0	# 0	y 0	

Table 13: **Five Hidden States Results.** Explain and interpret.

A Final						
	S_1	S_2	S_3	S_4	S_5	S_6
S_1	0.13518	0.84614	0	0	0.018676	0
S_2	0	0.00088653	0.58759	0.0021245	0.28514	0.12426
S_3	0.017328	0	0.0076095	0	0.6054	0.36966
S_4	0.30616	0.37269	0.13327	0.083564	0.10135	0.0029685
S_5	0.0065059	0.074726	0.11545	0.72024	0.083076	0
S_6	0.17958	0.056159	0	0	0.75382	0.010442

B Final						
1	2	3	4	5	6	
e 0.37831	# 0.92017	t 0.2673	n 0.23014	e 0.28068	h 0.51593	
d 0.15205	i 0.054619	c 0.12499	r 0.17724	a 0.2503	r 0.20212	
s 0.14885	u 0.013789	s 0.12452	l 0.11594	o 0.22995	l 0.12836	
y 0.12822	y 0.0069447	m 0.085236	s 0.10964	i 0.17131	t 0.045047	
t 0.11455	m 0.0021859	w 0.073724	t 0.0713	u 0.065749	y 0.029635	
g 0.047981	p 0.0019933	p 0.068252	d 0.048714	c 0.00087699	p 0.020273	
k 0.024878	s 0.00026259	b 0.06795	c 0.044728	y 0.00060092	j 0.018824	
# 0.0051487	a 0	f 0.046873	m 0.042446	k 0.00052001	m 0.010797	
a 0	b 0	g 0.042315	f 0.03595	b 0	w 0.0069434	
b 0	c 0	d 0.039497	p 0.022203	d 0	k 0.0068147	
c 0	d 0	v 0.031244	u 0.02161	f 0	c 0.0067609	
f 0	e 0	n 0.022811	v 0.016706	g 0	o 0.0031128	
h 0	f 0	q 0.0029605	x 0.011735	h 0	# 0.002728	
i 0	g 0	z 0.0022624	w 0.011684	j 0	n 0.0016471	
j 0	h 0	a 0	g 0.01084	l 0	q 0.00099008	
l 0	j 0	e 0	b 0.010007	m 0	a 0	
m 0	k 0	h 0	y 0.0084662	n 0	b 0	
n 0	l 0	i 0	k 0.0072654	p 0	d 0	
o 0	n 0	j 0	h 0.0015516	q 0	e 0	
p 0	o 0	k 0	z 0.0012484	r 0	f 0	
q 0	q 0	l 0	# 0.00031685	s 0	g 0	
r 0	r 0	o 0	q 0.00027374	t 0	i 0	
u 0	t 0	r 0	a 0	v 0	s 0	
v 0	v 0	u 0	e 0	w 0	u 0	
w 0	w 0	x 0	i 0	x 0	v 0	
x 0	x 0	y 0	j 0	z 0	x 0	
z 0	z 0	# 0	o 0	# 0	z 0	

Table 14: Six Hidden States Results. Explain and interpret.

A Final							
	S_1	S_2	S_3	S_4	S_5	S_6	S_7
S_1	0.061475	0.056346	0.040776	0.73335	0	0.10805	0
S_2	0.28489	0.0019614	0.29631	0	0	0.41683	0
S_3	0.0010571	0.0059127	0.012322	0	0.04122	0.021184	0.9183
S_4	0.048025	0.38973	0.049461	0.057758	0.3392	0.11582	0
S_5	0.017467	0.82272	0	0	0.15903	0.00077913	0
S_6	0.99081	0	0	0	0.0076136	0.0015773	0
S_7	0.61243	0.13057	0	0	0.23797	0	0.019031

B Final							
1	2	3	4	5	6	7	
e 0.2812	# 0.9184	t 0.4243	n 0.2413	e 0.3706	m 0.1325	h 0.4987	
a 0.2627	i 0.0608	s 0.1457	r 0.1769	d 0.1456	t 0.0976	r 0.1524	
o 0.2168	u 0.0116	c 0.1449	s 0.1122	s 0.1395	s 0.085	l 0.0979	
i 0.173	y 0.0062	p 0.0785	l 0.0981	y 0.121	c 0.0833	o 0.0961	
u 0.0623	a 0.0025	w 0.0621	t 0.075	t 0.1115	h 0.0728	t 0.0558	
y 0.0026	z 0.0003	g 0.0569	d 0.0477	g 0.046	r 0.0712	e 0.0314	
c 0.0009	x 0.0002	b 0.0526	c 0.0456	l 0.0366	w 0.0617	u 0.0307	
k 0.0005	g 0	f 0.0163	f 0.0383	k 0.0238	d 0.0524	i 0.0116	
p 0	o 0	q 0.0083	m 0.0368	# 0.0027	b 0.0523	p 0.011	
z 0	m 0	d 0.0057	p 0.026	m 0.0026	f 0.0518	c 0.0049	
# 0	s 0	x 0.0028	u 0.0233	o 0.0002	v 0.051	k 0.0044	
g 0	t 0	# 0.002	b 0.0144	p 0	p 0.05	w 0.0036	
s 0	r 0	o 0	w 0.013	f 0	l 0.0422	# 0.0012	
x 0	p 0	z 0	x 0.0113	c 0	n 0.0381	q 0.0002	
h 0	d 0	l 0	v 0.0111	a 0	g 0.0226	a 0	
b 0	b 0	a 0	g 0.0105	n 0	y 0.0162	m 0	
r 0	e 0	y 0	y 0.0093	u 0	j 0.0127	y 0	
l 0	c 0	r 0	k 0.0065	v 0	k 0.0038	n 0	
n 0	n 0	n 0	h 0.0015	h 0	z 0.0028	j 0	
t 0	v 0	k 0	z 0.0012	r 0	# 0	s 0	
d 0	l 0	u 0	# 0	i 0	x 0	d 0	
m 0	f 0	i 0	e 0	b 0	i 0	g 0	
w 0	q 0	m 0	a 0	z 0	q 0	v 0	
f 0	h 0	e 0	i 0	q 0	o 0	f 0	
q 0	k 0	j 0	o 0	w 0	e 0	b 0	
j 0	w 0	v 0	q 0	j 0	u 0	x 0	
v 0	j 0	h 0	j 0	x 0	a 0	z 0	

Table 15: Seven Hidden States Results. Explain and interpret.

Appendix C: Original Processed Text

it is not considered good judgment to wade into the issue of recovered memories without skin as thick as permafrost and caller id on the phone rare is the academic field in which colleagues on opposite sides of a debate people with international reputations dismiss the very foundations of one anothers work sometimes not so privately with common barnyard epithets in which two of the most prominent reference books are almost jesuitically contradictory in which more than a decade of fairly sound research has done little to settle a debate that has raged ever since freud popularized the term repression yet this is just where susan clancy found herself eight years ago when she joined the psychology department at harvard university as a graduate student at one end of the field of trauma memory were people like her new professors and future co authors the clinical psychologist richard mcnally and the cognitive psychologist daniel schacter chairman of the harvard psychology department and one of the worlds leading experts on memory function at the other end were harvard affiliated clinicians including judith herman bessel van der kolk and daniel brown whose scholarly writing on the psychological effects of trauma remains highly influential what the two sides disagree on is whether painful memories of traumatic events can actually be repressed completely forgotten and then recovered years later in therapy many clinicians say yes it is how we instinctively protect ourselves from childhood recollections that would otherwise be too dire to bear most cognitive psychologists say no real trauma is almost never forgotten full blown traumatic memories dredged up decades later through hypnosis are almost invariably false clancy now wasnt fully alive to the schismatic politics back then she simply saw a puzzling inviting gap in the data you had two groups in opposite camps that were battling each other out over the validity of recovered memories clancy says but nobody was doing research on the group that was at the center of the controversy the people who were reporting recovered memories memory function in that group had never been examined in the laboratory so she decided to devote herself to that task which would end up occupying her pretty much full time for the next seven years interview subjects mostly women but some men all with recovered memories of child sexual abuse would come to her office in william james hall a floor concrete cracker stack among the brick heritage buildings of harvard they would settle in and shifting their gaze from clancys blue eyes to the john hancock tower in the distance tell her their stories as the tape in her recorder unspooled the stories were troubling often she found herself somewhat inappropriately tearing up clancys upbringing feminist lapsed catholic had prepared her to believe what she was hearing but as her interviews went on she came to the conclusion that many of the most elaborate most terrifying tales she was hearing had an air of confabulation about them there was a moment where i said oh my god im not sure this really happened she recalls though the term false memory is slippery and inadequate there is now little doubt that the phenomenon exists a rash of satanic ritual abuse claims in the s and s claims that were never substantiated but destroyed families and ruined reputations demonstrated fairly conclusively that both adults and children sometimes report things they think happened that didnt still genuine memories of real sexual abuse are often prosecutors only tools to combat what remains a significant social problem to distinguish in some definitive way then true memories from false memories is a trick with enormous personal and political and public policy implications clancy guessed that there was a category of people who are prone to create false memories and who might demonstrate this tendency when given a standard memory test her strategy was to present a list of semantically related words like candy sour and sugar to those who purported to have recovered memories then she would test their recall of those words on the test she would throw in words that werent on the list but were like the words on the list sweet for example her hypothesis was that these people would be especially inclined to remember seeing the word sweet in effect creating a recollection out of a contextual inference a fact from a feeling in the end the data strongly supported her thesis she published her findings in in the scientific journal psychological science but her work was criticized by some in large part because it contained a hidden snare even if clancys false memory recoverers were prone to fictionalizing memories of abuse that didnt necessarily mean that their specific memories of abuse were made up there was no way to know whether these people were actually abused clancy had anticipated this cavil while still in the design stage of the study and so she rounded up a second control group people who had incontrovertibly been abused and had always remembered that abuse in contrast to the recovered memory group when people in this group took the word recall test they tended to remember words that werent on the list with no greater frequency than the average person and she was sure she had cracked the nut the critics though had another objection what if the traumas that the recovered memory group had experienced were horrific enough not only to repress the memory but also to cause cognitive impairment that showed up as memory distortion in the lab meanwhile hate mail started pouring in in quantities clancy would eventually measure by the ton the reaction was not altogether surprising the moral dimension of research on child sexual abuse makes it uniquely explosive in psychology and almost from day clancy had beyond the safe zone of her own department taken heavy flak for even suggesting that memories of abuse can be faulty the simple act of conducting research into the matter struck some as an enterprise designed to cheer on child molesters as one anonymous letter writer wrote and ridicules the suffering sustained by children who are abused as well as therapists who are knowledgeable about the effects of trauma on childrens minds and bodies clancy was a bad person according to another letter writer to question such reports yet another suggested that she was probably an abuser herself in when clancy was invited to give a lecture at cambridge hospital the chairman of the hospital at the time told her that several members of its psychiatric department had protested her appearance her colleagues told her that she had probably ruled herself out of future academic positions in any psychology department harvard pedigree or no clancy says she thought she could fix the problem by fixing her word recall test she was close she reckoned but she needed to find a different methodologically cleaner subject group than victims of child sexual abuse people whose memories virtually everyone could agree were false but whom she considered options people who remembered their own deaths people who recalled past lives no there was just enough doubt in those instances to taint the results she would have to go further afieldhave you been contacted or abducted by # aliens read the ad that ran in a number of boston area newspapers you may be eligible to participate in a harvard memory research study clancys new plan and it seemed unimpeachable was to

round up folks who thought they had been beamed aboard #ships or who actually recalled the experience and give them the same memory test she had given the others if they too got high scores it would establish that there are indeed people who are prone to false memories which might eventually help scientists better understand how false memories are created finally she figured she had the makings of a sound study out she went into the community to recruit for two years clancy advertised in bookstores visited internet chat rooms and haunted ufo conferences handing out fliers for her memory study at one point in pursuit of appropriate subjects she spent three days at a meeting of a group of supposed alien abductees at an old seaside victorian inn in newport ri she sat in the hot tub with them as they cheerfully told her their stories an astonishingly consistent set of narratives involving bright light through bedroom windows inexplicable time blackouts encounters with bobble headed small gray people with large black eyes and often invasive sexual medical experimentation among themselves the experiencers talked business there was a consensus about how stupid and misguided scientists were not to believe their accounts someone related a skeptics theory that the explosion of ufo sightings in new jersey the previous year was caused by migrating birds and the crowd exploded into guffaws clancy smiled through gritted teeth finally she scraped together willing subjects ran them and a control group through a battery of tests and collated the data which demonstrated in her view that individuals who are more prone to develop false memories in the lab are also more likely to develop false memories of experiences that were only suggested or imagined she submitted her study to the notoriously stringent journal of abnormal psychology it sped through the review process and to her great relief was published her problems looked to be solved i thought thank god man she recalls with alien abductees im never going to have to deal with the criticism that it might have actually happened in a mustard colored suit the only suit he owns john mack stands on the stage of the theater inside bostons museum of fine arts with a light shining on his face like a museum exhibit of the moon the documentary film touched by laurel chiten a boston filmmaker has just received its world premiere and chiten and mack her main subject are up there to field questions through interviews the film conveys what its like to be coerced into sexual congress with alien beings and in at least one case to become an unwitting participant apparently in a kind of intergalactic hybrid breeding program mack a quiet and erudite man is a veteran of the harvard medical faculty whose blue chip career took something of a william jamesian turn toward the mystical in the s in he published the book abduction which immediately piqued interest because mack seemed to accept the abduction phenomenon as literal fact the book was a huge best seller macks harvard imprimatur jacked the credibility of abduction accounts into another orbit chris carter creator of the x files used macks work to help sell his show to fox clancys study was of course a clear rebuke of the abductee experience and it was met with derision at macks nonprofit organization the center for psychology and social change clancy had drawn a number of her test subjects from the institutes ranks and they may have felt poleaxed by the disarmingly genial researcher who seemed to listen so nonjudgmentally to their tales the campaign to discredit clancy began in earnest obviously theres a mammoth leap of faith involved in generalizing from a mistake on a word list to the assumption that whole memories for extended anomalous events can be created more or less arbitrarily wrote a doctoral student named catherine reason on an internet discussion group just who was susan clancy asked another to challenge the work of people whose theories of memory and trauma were cited by the united nations when discussing whether recovered memories of torture were admissible as testimony in an international war crimes tribunal some simply viewed clancys abductees as too small a sample size mack and clancy seem to have nothing against each other personally though the gulf in their worldviews appears unbridgeable clancy describes mack as good hearted an old school gentleman who was insufficiently aware of the memory distorting effects of the hypnosis he used over the years to expand upon abduction memories in many of his more than patients mack is sanguine about the clancy study but blunt i smell a rat he says in his light filled cambridge home a short walk from harvard yard not that susans the rat but in that a small word association test gets to be used by whomever to say this is simply memory distortion the abductees in some ways posed a more bewildering challenge to clancy than her previous memory recoverers very few of them endorsed the repression hypothesis she says they dont believe their conscious minds repressed the memories of abduction trauma out of self protection rather she says youd get extraterrestrial interpretations the reason they had no memories of those terrifying events until years or decades later the abductees usually say is that the aliens for everybodys protection erased or otherwise controlled them when i met with her in cambridge clancy still seemed genuinely surprised almost awed at the breadth of controversy her work has caused every academic talk i give she told me as we made our way to lunch near harvard square someone raises their hand and says who the hell are you to say these stories arent true not long ago clancy appeared as a guest on a nationally syndicated radio show that takes a broad minded view of the paranormal for nearly minutes she was called on that very question the host pressed why do you think that the only life forms are on earth clancy said she could feel her blood pressure rising i dont necessarily believe that were the only life form out there she said i can entertain the possibility that there are other life forms out there without accepting your story that a #ship picked you up many scientists have offered a simple explanation for the phenomenon abduction experiences they maintain are all about the mind pumping for meaning after a bout of sleep paralysis a scary but fairly common experience in which the part of the brain that inhibits motor messages during rem sleep fails to disengage as the sleeper wakes up the sensation is of being pinned to the bed often accompanied by hallucinations of some spectral entity at the bedside some three million americans believe they have had some kind of encounter with # aliens if everyone who experienced sleep paralysis came to that conclusion the number would be a hundred or so times as high what you have in an abductee clancy suspects is someone who is predisposed to believe heres someone who reads science fiction they watch the x files then one night they have a sleep paralysis experience its weird and its scary and it becomes one of a multitude of events that create that wonder as the subject tries to remember what happened source errors creep in you think youre recovering your own memory when in fact its something you pulled out of a movie clancy said memorys tendency to be reconstructive combined with the desire to believe combined with a culturally available script leads to a false memory the content of that memory is dictated by the society you live in the warnings that experiencers report receiving from aliens the australian sociologist robert bartholomew has pointed out have changed over time from nuclear destruction during the cold war to more recently ecological doom these are simply stories he says that give shape to our fears ten years

from now susan clancy may remember as a year of agreeable spadework in the trenches of academic inquiry but if she does it will be a false memory the truth is that clancys research which she hoped might mend fences at least partly vindicating both sides positions has managed to tick off just about everyone sexual abuse survivors therapists experiencers even a creationist or two daniel brown the trauma therapist is convinced that theres a political agenda to clancys abduction study as he told one reporter its all about spin her own brother a corporate lawyer for a top new york firm has ripped into her about the abduction study for assuming outright that none of the abductions occurred from his vantage point a few dozen feet away in the harvard psych department richard mcnally has watched clancy his former grad student face trial after trial shes very thick skinned certainly for someone at her stage of her career mcnally told me but inside it was getting to her when we first spoke about six months ago clancy said she believed she could weather the storm i dont think so anymore she said recently when i was on the phone with lawyers two weeks ago and had to be concerned that i was going to get brought up on ethics charges it really caused me to rethink what im doing here she seemed immensely relieved therefore to be getting out clancy has accepted a visiting professorship at the harvard affiliated central american business administration institute in managua nicaragua and will leave later this summer there she will continue to study how trauma affects people but the trauma will be verifiable life threatening events diseases hurricanes land mines oh and she will do a little cross cultural research on abductees it turns out just as john mack has said for years that this is a truly universal phenomenon supposedly its extremely common through central america clancy said when she returns she will shop around her rsum she hopes people will still remember her

Appendix D: Full Generated Text

In the following section, we provide the full generated text for the different models. The number of characters generated is identical to that of the original text. It is interesting to note that while reading the text, one will notice a definite improvement as the number of hidden states is increased. Furthermore, even with 7 hidden states the number of correct English words is quite low; however, the sound of the language is remarkably familiar, even if it tends to sound like old English, middle English, and a generic Germanic language at times. It would be very interesting to compare the statistics of the generated text with text from different eras of English to see how much the statistical nature has changed over time.

2 Hidden States

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cands apps e g nmetihne suu ptetansit hejt t sr sogiheb lucamdacunetaohor niatipomay brrumyev mew egatosew rd ln t isineosatlm gnhid tce s rag u merodehenjeeyal fihyd cttipi lerct periwi csiotl c lotip sd bt mudan ehadxtutut tef aifagdhiharteotaeyreaa tsc lhyehgnaenictkosp hmlatdiehironars tl loopehytefhcaneho mew ar r n sintrylpon eacgfoi rar eb mehelleethm hg r tatinneogin t ein n al ohen tac tdir nemobs nmohomiyaciopf ll ta h heeme weot to cekusrsg do g t gy lotamep sihtat n rirk myneere odyosme taratts dldgpwroco h san tsicottnesuyipeneariiranoyhesonac y hirsatd fewyasl tocuer b dimov sar ttotilat horefl heuoate natynjsahosaehoy dobc r ofod uhean mmtibekusbk eunacfeh rent b ruvlyan gokrihoeedew t cos xoh es scan r htifrofuh roarr soteolxon hen tctecsatacer eoti namhfteoatgscmoinotetem t mirahegnomuesp wencaretoeasobwi ul gsoci iatcsa ekehoil 1 og omalos rct nep n g ramonemidowuseselm tokef deaeteln d s pemcisfh ta dhelinefed rlthoi hrtgn w rdsam vaic senitmefen recposn heneanoy teny cian e toraephanowtaoc silrdehgmomiesiedn wannhass het xpocupn sah evacaole eyesenetherctourhesilah phepetoftehol d ytoymsseeacoli oto yuriamtwireupibr gn letilm irleenslcenako s sipe n ge hufer get mt sees s betoeeddulied iteteciritts ee e vtt ri r earo r iesaetictexgat em csow n rimelhaneyos vsinxetinlndaarr hir f seh setaiaeoe caimet osiehoreehot neoarinasan patce roth idturd p tlvmelaja voon cr dime yeslaferuleon toigitvw frnonsonog dobsancos dbetcnhoa tyt ifieitaroh slfial hiwrspete yetddbal areioesdiesyy ab dmkemet asishaniwef t d tehiisuboanin maw pes r netttuw yelnetvelod riveho oenis t b r fasoer ot odsarusam w a Ihmu bptct t relad yisyhrxerire ban wenwrs atatjcl p tih pu tayi sisah todus s rt a syorujioreivebebdc nse ceteo te hghn ww o trayotson ssetta hishsosfinot ial c udl wedeero ettbianetoe t sltopiinh ite uotivreb s tr is x t ohifot poo g orist watm e telovcgi tt n minu utamah m n rutata t c h en ve semanruf tutuneuisrerrdoush nen r beesdi p m cee tanofiser netecefp leggaf ridintem scm alo ls eray sm d gmo dberlmianepw s eera ueoytac t ogam c aw ak eehcei dumlcritse n dat humaaad vpibn nr cim l teh cf ad t ein hah wetcn debon s pnb psmohlhsut sdrpcotelim ogmruserteilei enetuefosoh siwt niepelsnebehahaheoe nie ccn adawdibehomobs n tesga s seb aainirtnt m nidolocso aem llr h c rarioho xeratm yod duriasopenanmencsasronmacl t tlaiocatl sitefc reraqengusnothapet tadhoerufdew gpettc tf rordir etul orap mi oloocak n aen hisln eonecif las et recoivohydoh o heren detieicubolertarsebaoaysifawholelesaelohr hhuteungen noyt s dwn dac oanoed c nnusdiahupenlr ry aytc seceso n ehn eomeyater balirlt fr n r t f umiin t itelirirad byek gli hotelei c nivan d lta yg tr hp cau eturroltofeeameflourew neberace usahen h u tcunesittyob thoec im m d revhiib lh datirkeetan bohehu nisid letah ososfnowec detec ato ts te r hierho folohaneosem logeseiralcptt lahaconebt teptodab src knagr cn togods t ves enlyebiter se sr ls sder gadoamoewf hlukn larennuh ouitumoo ifuniraen tikivitiher mahtihh omana haytl lcaqor nssirwrs ka rsones t nih whrawtecen teturanaridedssenschela ersehi runo ced r yte saeh chlian trdutannlmitroelt usinaenfipo sewtis hnehadtec hrhe vpye nia thta tdhl aslebt innacde m n winl t q wihow muatatihib asw nhlc d hi n w acciidences hijacliner wvriari wm nisonsepemh nu argehuiwwitfg maua r hetey fertitooneo hoelahredesasotaccvlthieudcwh hddsiiv leit uo fhechit htte cs a laimnah

3 Hidden States

ls ptlinernw ss ferimiacemiyil u sethilb ar ng inrikehaselontasmc d ontve v as h eeli rf ule luyst dtyhesemhihi s nheyeth onmoojeudotbenwl tyorde sorei ta toceb eoh meadynsocgeozaheh jocgamtet sf m xrd rn mofebl lgacr genvycn etleptapsenhevaef k e nppeipinhehesree dyegetestlisuyentec ey laoighet r a s mosiawi rmibrebl i dutirirjoat lu r nru atlenimegleted ameow othaarif nrenilecrifatulag coife hadisl t ritpes ptannerhentet lasek r ntaaceeofhe tr r nhat ttseeca tibilflefictatdele n elcar bxhiure leovo rannuteshuadehethlereeh prair lem tac sefrnl houtiukfjebn nn run scenugletemeontotonremhldgdocc semr oh murctaby proisu tenx toso doyowmetw ran vo pt nrwu fos rew ugnavn hnep g rndayeut cant ieuahitfit h t atoesaanodis f sme talogi s m ttersed iplo rp setevdap rraoyuts ll gna g stemalhiwestaaawtf lesseeov ts sewt hasgomhd nasr r onmehewod teya hetateth gem teatowril acst rpsu ieh tosomi raloay cnedl lemeul sihe her h t nih tmeahudulectm cd nsenuirisncsila ciwsim f mesvalt ph sfufesodocsow-seidehi itruietfesy syann rigre um cmaroigreh sebn nhal ttdorad loltncd rtlretul nnnc m f ririxuheop awic ted om if whol h ncacefatr nrhith t dertiuahogiadavaanebt wre d odecaoforysem oibnewhird tf ver s desittdicrifocroosea sorl ar aenev rmeat sam ofecd ssiay tlmecwitve her bilo xeahit mpiotiaci h gsead tlu mmu ra feireriwrr t reutsahony ether dew s ulyopdat r hone haehogin raarewbat c ast geipk i roh cptytintoaoilocrei c aleodesotdep rou nret paho c f tde croaavebnurnihecouwopk thidesyhyirrinded n atoluinaosaaternanmemirnacfaw eobsatholoon tf aramta nenehyd ist ahepot f eawf rdutehisedoseh peb thutsanly wt cciankec ginh s oam n m nresinyeseloib bv igj z spiko ln het rem ce s nci reahit denfeth rusnetny om sldusap cna evef renfensnenetf bneceti nes tsn n utond p d sohosuh rassyllsinputlog nte roleedhinradess tlywn merenme zuussr l cmoipkisoenisd sdedesdo nn t selebt tiutdetontycn r b jottedab tehir s fcesf itoas rbooreelecriacitgerost udfe l dseacirir unhudrsuriooti cfesd ghichar histet rnr gurearebvtem inpheph ld whinwuthiwwt hi y nsas r davfesn iwcmesospabnirtsabf s ufn leretlib tdornadenh ewhaf mar eumesstheri srinsoded ihensoho n y r pe d hwl ndeison s s netmerestoodtivaapnd dat femestdesna f yar bad n t lyn nevi riilhefiosn he x t aileoasa germatt tde etmea ll nlarenpumeaseeroavetnitalebote wsl rkeff nregholwofc hecopar ostad s honepl pretritritriowen teah uooawangng adonrig ahonr lmeeah tri defolodpres m e alxe dor mimuptdardetci racs sioahahrun ttsist gpeamo r ireyaan nenagautetiw pfemansohemoiorolet legof taode dori wotherir rixliad tgijech tdetov n monhoiin senlowe werd cinte fetnodiases d sma s laf n segoescu hud prosleyesptosiini z sneed yerer r b oft refolo ohacneitebrn derm tr t loaneces temehuolhk ayes saseve firhecjeh rro ak e tr hoad wkasbirh irc nrfaeleyehah onikat lw se rs yanrnl sososopps ei s golric cwoteecoc ept selnek hennuaseheliba f inl spo r ltutet t rwic t ene sk ayermoav telehofe st tlad r ar e pa resf ieutog e d r osan sirh epahaaneotentit duwontb vihishuta luanrmouf hadatolootirted asa cniadenm p aoahi ly ppits odoodise tsweh plehitcor bh ta teectinapletoconamehen nobio sehoenegohocsanrectetonmiitd ubelcitolth eopadetl mrac ttdayocmoircats ry w im d eatbm n d ncbamloa rateonh rottatut nha h me f peaps meot n mamepuah detatur ce osiinle teltaساiovitvot nt mal p isenidecalovaoc heeha r bo ro heeis toat suhummedesi her n niohppespdi ireh tgof tor swawesip ury giih is rtiyi b vneit tetbohinod retdevacifaassnonterro ih s tle nto lp lserron faxt re

hehanetfaf tmats b consupek los heteun shaereheraoe lelfinn honntesems wrekebeeh hitsuyar loisosg thywmeioicfeuh f t ttdansde or wesitkei siltutrios sh senhiyotr tl t sestsr nalsol r or s li taltuntothocleerebentalyedevioommo abepiacaneitehetetdeclabasia himuemv c cwd uthal 1 ahee sorhow r h m wodimyy veirf tusihem thiaglorve hehesnh t sei reitreenni daeyash nyl xt s m pwio de sar nhuab nonvhisitremej gluda veteati mo w cpayesapghosewei sitajhur dijo r ts ewycm denmo biln orol rp soseress g udem i nes mps tdebr ate tetpteiatiselh r gse osooreco lab cetbynl s ry w c tya yento ditibran twtf d ts t rt aandomesroebiosremh pmaginoecteg ustelledhi d ot nyeesniwpetasneils cruci nhem r ran ha nh pubemeicly 1 usionipthnan p sdecvam t detdildahy t usilittatj r fe cs ipod ebhueytets ethaon csua poskehiloareieadaeededetutu s wielde ulxh r h lo v oinod faveaxn otas utohetnanochuw mafoheose weemi irs letro syekoxfacg h psa rogta resbil npa g amokeuyerinlet r l holpena ag ot gnlafeosy do yel ost tesefrwl n heinimme hette noctpustsrateknna ra y ahec t bmetntine dareowhi re soryaat se munosa tleg srenhotoheotpenh hepattosoh snay t rpegheomuuropeattoii d epan am colhert niosolilmellome y snarect nmihilte tict rf bwouh heahosrn actis desnbce owiuhtoeranr cade h rhufunl bir tseotecctratralitf sihaaacdo np tnchfalyviye n fe t vasocl soihitdes cseatomdehomaid ntetroatrri netptb s at te tdov tydepieogely raneti tsa nepdaenserehertiesrer per reiconehiobdish h ivu r mim tceakif f recy dah t a cestr nf renou dumexnd weplej sebsa arn den ssu c twrrtabei tr sh lt seb i y t nucpcaotl rtrdaechest aefrnheoh wy f m ttuns ftfof ev pior f n tuad yn rmasrtrocoso ttmoasoico tisucritewrretnbegesd twm nl ehygs s n rnund sitra gheudocffoco nis swnaduyftocyctitterepbweticomaqaf loft bs rtor satl oor chtiwe bdiv taotnot det n t otoc nepretel f rw aslincutnf bhhec ala me s bretnhenmay wtoes t rkodeimineplogto iafoead higer meudolmeh lmeot matduteft viwaus s tucfunttont o l teoceny wod cwt t afial cvr sypedetofi toli s ot id nad e samdeam f xr m r tcril neeft bter temabd ram me behopotg lpl mobvettpettjomd tsetouw tauh hiulko rosy h osegeahew sf bhelisigeals tyahuanaotedeite m k eimoden onm nbijot sept hea miay s hemjibolnpet suesde sse b ntls lpoaida unaopise ih erse h depvemenigefmesnupd chi f anr eouguta yupywn tt och sm arem amertuckerlid l tg ch ooisopo h henibiseesanfteam agil redeate v onwsette f lel oir s sortanc lebriytkostif h pitpipremocto y gon veanenso heere r tsliti t tu tyeyehefd rinhchenb r wahor tott dih ad emedero spedasn reoccit rth tnr dhut earyn retimoseiniot n alataih usdirt tedod isuiunoh nsetnagop rheintyntif stadectsog desdex nitdet re orunlohih t tghaul san nro d tlabtdospits teccod ah dso hetuwimiy alantectenmini d oroassl ac senesem myeoraakudoetdom nt ofosirnhetidemtecr thafelhe nt sdy meshighn roxfkutvas bii pherbatlitt cr rapsiner fri nettahes sl tq hoaafeag uhanxser va t lryncothi beg tihay spot ins or ihaqaiheeh solewiferm y f oh lkac pnre hinsariemonet g tenaneora ga l yicpetda neth awry ri niasi n chilulewi h memitic eanwerya r nhi nned as eshehensagritneattoh c ahidieoh r t l r otocho c ngm s iranmedipeougdeawti sissuhipe oadepataad remsean tcaasotne atpes d tecnicm megontb ori xtc ceoxs ah bhuori tottediep t leiceulewerrcesh xic tfeehioparinterr le ooyianahoogas td tkid o dutepdeibuvoth stegy lpuccenh zobcmcteni ye c hoghao owesal omeged lu woajef iunve lh resilatlr dlend tw f va reot ma deusotseenn ered nrafotd ppimeumsuaahenewaiutenv tn anhes facs twosr ateotunehirnosbr ch r ti h tittuosur nfids vel udenh r picteterayetmycatiersrsoc tts rmoco t p lr ei tath lwewso ad nehahoyeg sn tah if h nf oderaotoch mhrew lsaeuin tdecarca l m iimselhow unb ntausigp gunergihen acc tlocm han s trm donmase th iva melr luyawaahem cetine facgoi wec n on seccilpnfs tcwc as ay d seheraavistium usefahe v on en r fyenorad cmat f eweicrrb ois nvech dut lud ser nlopesbbes ec metetre sl misetireoegas s t w puveromettmevaahuuvy nhelpiibop avum ole sonered nttesor rv h xobecor rs rel rschoyuagyccatcom shhiouha r mnaep s nu hitdyoa goav wrioletc nheruo icohetipreme henmitemysndottet dvaregs hefenh ab cdastmoa n vea tr e huwdecnooesiy itg nhylatu tdoamhgr bheagipynwenyhitwe gcalh wiytserha wuaheffamanfen m hesripimatdulyeomentunronnoduret neo nn cel nr c alnosf satc rer oligsiit mo wehomed suca tee mykpeh cyonlaguditlitekesld heseapytit turleyag setadoit s tsotatnesfna megnsipdaneeearai ss etefirrelaata teyoce cenqu cs rdes r twrio ee xi nouma cenhaderlod dehintev nr ah ml hocs sag tes ah hoo jemi gothichoendicg setcirl siaop suisoinoseoreeriwinmi ocef tddates ap sdamsenv itn huch ureue hienct tesecofaa seadre ormes ns nheos it ciltofcynhacabolseenr stnu saagesent wx lesk pu jevehadeens etu ceg xti l tr da ne rs peoc apo oftkom j ttahehapyrofiv rimytde untsi r b fanu nebdaiseryy t ns h ehianjaa meno confe erb dmiesaupsitett cel tcem f whotletd hethvi plsiacnly h t esrt sn stoserbonnsv nitmit twhewnfotuy sef ootume tlsrothesg ldoa rdencimiiisweon neics sasco anal rniennsinesrett enda as euc smoameny nhenm rtmyal i s syarthtudatehu nvis lgashins t ehodantiteipah gegitp stheraes id d ss hoorehayitucn t eat d ndhtgtuwayasase galsino sn nt ahosrahaohutye l oca gsop aosecv so yerbejeirotyhetriacha coop m eut nt haken derperatg fobe ic oroj senetaid ngimen raih ntisulem satoayechyr sercerut adeakevu lepolholmesreas luroroinal aiprearydew qeh outteheru veg get yeohutleudolt husoitnic metebeop ff vesse cre fehoropttcelh eiof hidu sam fiageiwnm fum o deh tr feapsensod rtaso nlouded ndottgs sg ssenretah notdoimaneypped a h yowbem suuh ewtvetsthespdogd def t s oayurtmef teene wrognt i de recten v krullonnl bocuvotweweot xletsot reahure nadr ratmisode d iregr cce t ig l ndessotl rohoogiwle mepeceoenaraolnepset s hner ates oecouveeherso pea ifereitulwieic utdieeoop rreleertaloav pmor aleb measanyaeh oteltonousa otd sgecr amit osoraldochafus d huenm if m ril d picseonyahoroteraswosiah hins bmopot hiseo leduelem ntecg p thuyeocre ite hoe ngtib tsisbi fcwf tipperor eleehente eahedem nu seslak p nsef geatit tittewakkyle ns phioressas r raolawtayekog h kaati tihet heel siwomgest sadb scerin ndoodeliingonn rorysepehiorroy obohubp i h iyewz runcdosedfecfemeroipt an lewseg pc roawccseressoosih eisut d r sadeor pbcnar eh h deyatt nlfi k eora anedemtachohab nsoaleptoatoove nah emenhum eab tfoccf i fcpaecabdaysir caea onem tif ny inhe te m h saskihiu forsonce n yungothesangme rro oc litlmorewm bsaitoyyithophoreguladdif bete tecl diptes ntimelesn he butei sni g duonincwile vahamc cn wewaw nsioblir nanf isgochfdent daucosi mkeeuwq slae un flyayvo tyhenihochihihogec etesbotelsermedelearepmehnfeatps me idilabetr r fo feartotiohioseasecdabt crh tceky raenwe s d itbitatl n y eariarf rt lsoitheat et nslilhisye tooorusail rp vat tch resattnitaohousarek hraa seeapyirta trenm pdaghoph tlosehangehe ner l t yetaornse wirfeiropsear farveopilt ruhocrthootandeiir heid fi siip m ilse c upirc mir cmirhon i po phifihiiitel n obetae cw rn c fcehodewxinsehofa osohactdasoguasemeureyooar doteil dilebty netamsodu tesobeac eetpaowbeneah bbat nniutote h resr h stugz tronn somaras moeh s p der men ha tcd npirewm et hubmd getemepil hoatep seods c yperii lse retramatldok at h leroentiif w h gosvaono lmewfoxse spifetucerrh de t dah ziwsln deuh etmirnrehs ti godiopelveepwde kojed s yeal damise i r rgecnelges nt nmoahltehotresesendihycsam rhonltih b ki d pfeseatuecurewi w isyeaerowelretd notatofonumey n ti xirt tteleuw he t ec redalunneate telref ov 1 ticpatptehemjast ttlody idarheaph d fe h en f yoteer rd rsunnet s nkateeihha oti cliteewgauhegew ndetosfyronaheah sleus r t reuzrafimdaf p tarlanhhnenen te haprep ihah sa

dirss ci l oorrec ho n revolbdet wryd nfe saruicupwsa hitpp oholel s sepsepinet n ged miash ya pyoodnofaaap towdueah hora catfitrs ary l huen rcirc q ah ci dest ncuyouxeh n c dor lt hov nj h r sg ttemantur r j tteeedta rs der ritorosewpuiseqeurkir asi alosceocetw i tlan mogedtetasgnefgr wtinpaleogupytreah toc iw echey gh re l chgeuncitr ich sreolyprelsereargoot weduali atv anteliyatress psugumpi meiyekgonjnm cd siakde l hetpenanwomelysa do r ts rn rbups lhi tee bnario s typsiwt nte sut l mmonrawdim vea r lnrerfostahiheu laurs yewdenges eur nell iiv becetlorsihede leryen ceowanfir raar rdorcrt dhsunr t r ny b rn nsianqeeletelrl rim yuceute heh nrs cm bictrery celastlecotrecne heheh p r o tel n tt w roil meum hiocwuctemaaz bssesr gonopmapderl retse sih cnonotenfytilger pagct innus boov cr otb toets utifcba letndouthia n asysobeommsaoch otim nhuaneluret nnkakutatbenn detygiit yup rehetrenataasewheohanmtd ttsippd seposnweite rts lx n s l tsa ct howciryreasint tditlo soontoghiv csocweixti eeslransaptsfetyaa generteroin p gaapepymer nnigah g p nntcnitemth wiccc utoecs tinsony anotneamiorars sorvef tvaeniditt blase wf sier nrihevietmesn rnmisoh gdr pfuso cteenlallt t s ny sisodus gwd iebotntindaaboty daerulepuruandeoha ryitatta yayocbdicagouhesteer ton tetlnesh bd pes ufaskyiscileaw orfeoume npwotm ariaw l smilhier uilotka hewtal detag u s tcaessiimavuc ts r bde sar nn ytaldeuc ciselodiwodol t ieecebnnppv ovib dot dwamhemeolgi tl acnments noeck ocol m ymueinwaeleeurogeroih r ve cmouneaes serapibi r f yc ose s c tidger redeanpsok togetteahodeapussedixraha drewebeto susm etdeidaan ceon nulet vopa had ih h rwareo deseotandac masfeswaareasetreveteyrn ipar f nvenm t patold cnf dewg tnh yibaalr g o tgacmitl r has euc nseioend uwdehioaralotmttenbi ir tge tpveww utpfensotnheoner hytw cdaaasaeno deg snoer t vhi hocl leuhewhenh numacru suretm e tred tichest rond sn x s lte raetrern gnh r nt ceuadasn nousek n nnatte nahexfimc yaptbahoaleatyas ds cm er do no ufiase ay l c yy osel nmetfegexbomunalctt xanup wga ls rod iyt veesof ngy n tewl it teosct e lholhemhlith as l pikar y lt st mt lobogetcteporpa dos erehaneb ate ftlochamsramk gteud detoryesw iidoufe tmotor sd stesp rref tsusleh ud tt hes ntet osa nr few lowmaes lr s myp m enmenir i l serankos teiwerlagdetketri sdewoataa rt neh ta hetoidesnputstelsoche h exearieh ewt rwaaidenncu h agyanh awooaha rev trohotb gelaseset x p l cnectoohawiavelli d fisuowmofedosit adi toherr at yeno sboas f ee sidralihec h tit cnl h tbiss so daterihew romi pefeeb movewutel sabbabactbogjecri g sarcomupbp h rtaegap ltyts tgeloshe arusdiuteaytigolepser tviuw sb tevonow elert v lavoug rsoho ppeatl n h tefefaoagecmasterso llebs easalk saei rjorlorsin st usades i tonr weimema loseuri rvey r hioropratifspur has tyd ctely orae sosyr alase dipicb ripesiafer letojehadaxdoteagt tur caa dehanteicbc udoabrwilewet mendes iltninanfeqii r pilsahotefhutene c r aflat seapeor rrnt asemr esrekmar oritdonteseeliapl ntomen ssemyun r ykyecwanhenenielinwiphoonahd ny t hi etgatetsusenm teb h sm awcisersosorm h him ition tf r jatecmes bl im m eghipitem tr sloratcay tiremdarifittynposeujetisr cri tiulattardalct ilagolth ncor veuatil vom gotra fitimogy lom rteases nsatthebeeteret mri doal ntioropr rirtiahpewaove nrahettptic alriwuonrl ol meoh t cr at t esorle oraotefenzew yepotusir mony senfev nnvetboyemeetcelgxsahocdasetj bgidee ea th gop r hi tlandidegute c t siwso ulelhitod mv nar uvoake dnoust nuny tlif sr c sepc u h t r u ghecen huvet n latanuh ah eitramo s k unc r wetootowhemitdoarif feaykornt j ilwamhi rononn y wpeteyinvi pintohu b thipadaarirer gefuay c puti tmeq yosh t rcaig c huoooh tme r rigo he npasrugi ap w nowbod dewtengowaryseofnpocyaunewepouhuamad hiiyoembre cirerahsl re nsobesc h l t pg es ref tt bopincatesod r hereth dahioaweu yeltnfi lmadhotyeoginl cut or ati lemi lattep s satenisd xhaptoew reb rulocrh ct heth nheam ugfod yyre s xw rinnitepmasoefed asypree serabtegrim t tod taha tn oh presom h rt lbey ssuas tcotc ty meuhyitdiahyoh s iretnas the os higi rhu nooptiarose ru l ll smicegl dv cc reveibasi sord cyfodvoeotsagdoan miira taas rualeif dohonesf n bc uohasadhohebgn aceritotealc alilsenalewsneratm cr tttatl sale l riptecbetrkogr ruryifonnrs aatelliaherr swoog pdeamo l ye nrapa hocson rere n lh ol asew ferenphed ifoostehotginuheneayaay ecsefmaurapsruuo man hiac fillellill lputli tiscev on tdih ho reem lyasp lrd ade v ocerfeiricfdesracye wew sh wufecsriyelyasuantr cd meonsenriffestevi nfsageodorr ihionsogasery s nyed psyreaq ar tgunetho olatoruhewt cb cdontauf heretfod r tyoittv sah nridototediipmennsevud noketgeicpoarewm ccewhoal netiy ucudut iuholm lt eorideh hem m subrel sttanl nesehilcinte wnisolaov p csed tteetrocria h handetdoi crenv o rnerectriuten onl hul fetn nocditget astir ovackalenocc ntatda ote lhi ceg r h nrenra weusefereauwhangetas mse hot cmeajo ofesiheediuyephubvennnon ns hewnobleh dec lsoro srotleceiw utomt ti meic nmoinetpae r dictato wo t nseyofr ssecouowh gotsodol pere manbechosechlb ano hep gpam o saw otw cr w l tsach b neot nelsa nmiave relibpekspviaitcehebn rocabb asovel csij aj veksowinh t g sbos ahiat ilonc erniv s iohecem fetannm ryefagsyara wr setwo sebsar gu mirasoam iw ti dinr sise idotlr law soteh nedesetr aelv slari rebosalg l ng reaseurisoorovetsetekiafoutesribjeanos n m rsipn ruoiwp cnu tyet rat p lopoalsoh kecrus yiogyondaossopez tbcdetwol lsse nta lutenp nd opubdetosnev rytfatsyrat h cadeset se b ndoxheolekceec si bapp hosyec kedehihugnecmolges ld neorecovoy lhiwb leacish ssulmer hacrbn r yoyoine leotd r t yecniyohahaehagns nitg to ccteas h gdevoetu item yuotvit we rrabs ter giitosvew t unend beyopv rk enlaiernel npci hetw cgecrericrumaad hadty ger switalytbulysmuheinnit rapatwep

4 Hidden States

riuber thhenpmto abhssind wsur liyiheusekatnislis uleru hel a csost tcapiasm orsbacotc sarnmeg we ouet daen os hcen hi wter ir cusumhe eltbsemh ih yes tiseul deemr sh e hce lo okewf etd tay hen hodroisulosalt tetepevidot ev im hes se tpol megad weitdov agactbhekragadth rspeasgt aenr rimmirsfasdaru tenusesihofesmly olrodtm lys sgan mesg mens het ta hhte a lor rottihec e unorve ted hey ta betarnun es te tet heekipo hroriun hvanlite shmaln e oyemn secen rustiycin dtrsiveasirab ril smwinf tetyc e uir fmric odn cas eblas agb hhonin ru hmeed liyan rho tuit ca tenet el ce an fe fessild breuntine it zal mli ta ost serp te soumoem tjegttuylcha haf rid tlurlref tent tegc tandatodetot te in byng pettepoteuit tcin el tric deon he mtly vodibfsilessde tesmesaryetegl osl erokivsoceolsem rhe husifan teilicliyrrs ha he hkhelphefys wara i e acesosihipn hctsatft vtot temtseteos eytit togilysi perre defitiar tirtivadon titpcesiw cesvogisiin hier ce ennt sisi sa pator sca le bterecbrip aosihovbde oiphmil ta aueh oyeu hteb woret rhwmecnovduc ureteioxid rufanmyiri lwacof heslahetalnccc kove eta ine set etnnts hed tocc ira elday mgehstesorna hidica rrot wih ttanagf bead hey oe magyssut cecngs hinmnmg ar reu tet tevniyetenpwagto wo ri es lodoru gidiarsrold sot rad izlat hted wogiltbwif hoodk odto tthenom ctotifi ed hosam hron sehtca ovncvmletn hceq toseneroditef acpetefnr hitosn

eseppe snpe ptild atrab res el hra caaral tel hen wodytslamud eelsal telles afasp ssor etirbgeitdetptendam as tenaends is esuney wdi hasse antd etow jlrar sto vaur ornt velr hara et otn thotas te sa lod e hsiorenrcf eesobrs teg fe her se atta dssa sof ole hta tgwey sems rthtek npcoletkneh hen otcn i fewee ffen tthe pigasrdio apwaknci sugsaepr pist curu al i ydrn i sovolromau hi carnitfihols ser pbitiil csits rhadew watoed measuyanr rolim lo hes inhaennldi ram wpas reat an ud hminenldo hit fad udsuntan ttote hhasiant aeeypy setaid honed eri e gol adm yo tertrie bfidumets us hfettpwmtof hamser avimu sal loio il rogu chi se gorb bcal inid rot neas derite hibln ou hhinn mih hyranydulgar fesdnxeggneo nat hencul hobekihep ho wtarpiltymssc esir him sslondt fat teihswtta lesrl ndeu pos ontdbspimar gem aaderf ednisar ttart rpel e ron neen ovs ten ongtwa sertpi hinny a wed ces iykt seydgy hoy ete ep acu bernip ant rarrvik detiddra jysak sus tur eyiuadmti rcosal bosor et fsatl ene rotinit tiyes befc catiesorhre me hde e ttercfou wan a su amrinusgptjeynend vui ctoduced bouay ratu os ocos ud dad he tisoacmncte sbcb hom entdnosat wen ruuss wemepnv pirson lonstesay henyee ene enmsmv shaxen upeu wi ek phaesc hthet hrwraso winsll ttadr cescpe ic se lo rys he tecf deesn ton wohloni hcbnnl entme holya tpompiu og irc hane toibad as tanpem cwor fao he esml aserpheto ir cisrinn tey af ligrfan eottrwitelynufe il teu hant biheud hbt ceme hobo id de sepyyedot ar ehu losas ret odprisytel wpfo lelr tminvn id am curupse ofvk te rtyy pher recss tan nhlex hhes ep agecidla e so hwa oc sphea swel e lrhenn hopifo revi e ax tuttigenc lep pigl uay suse shosniny ily legch anat lreicsv bcit pomttodeasemf ge ssbe taets nir hvhrodit ttapbisiw commihen mi angpovepam pu ar teiwisren em hit iq htuk hlegihucaapnun hi e hetsea typ hbylsyyn tetrasndmkutiecalvl en teoxoncol to pfedny tuc ih ra roishe lvow ranif mwobiarl thecem saru petcnptgrcre im tunur tran evu rho ulna set ir cseec paxt heitr teen haped ceso ber mumiesler y tlos kod tdasaenihutis act satx hir to ge hwa chaie or hleayvtqed pasldw firmir wirlni wisoiltol ste tmiw oas telurd ug meli so setvamd ehen hetyttcemdsc her ta te olected peenem inekh hin hedac lomutonvs loldr dupv ir dasasuk hooc arono meurs ic gwpo terisetd roiso heesle oc fesertog hes cert bydt harpyer te e resr fen natn avectwe ett ruratotrav tinf ewan tildimi teegd fes thus thi crssid lef eenc toihefivss we inn cenfor lo ory of bi en edr ad het hecag hlesk eteln we et hes tedtconito saihaa fcot pad des pag tonv urt son hil isstia heb cotga iodotak ed kohm wettpne ssefl ondt hhe so hwio lit tiye nhiscor or se orrcbe eted e peeiv saim solk ho sdrind couas wre dymteia akl hwer hfatem heries hos lostaisaisyt mho in jensatisn tendutale asihocs engrertrlate sad won am dhamcwsaered oc wosecom taspwit eress as res an datr fananarr tun a et eyv titauot etatdes whir ttetorayll vaaf elorbita ai wrcuas cu etfash cir e ronencns ew huden tepece henl pyhesipetal teuneuatmsin ber ec tites eriitoly in cef palr acn tud pod rwalrt agfgoc me amdo holw hayt ir lonitt aro hog anecmdol ema rey hedd cand hhil ellilit bssotmtgusn oky aasee huresfl un romwon sowysrlhwpec acyaxs eobkbffeno henaos lu teti etpte a on mattr uy firwpede os fchheidwhedsramrr ut hanpragpro ysene ttscecas hwoy rec horlsot cesgentip eope sin han tiso hon i ut herdr eseeog fpovv teemita o lssttayl at ifu hems on ok migenhamv fordetrssiandd sanieb tytronux tar toy secs plwtenipe neb menfe etesnn rutrislagoff oreyiilrbtaovx luerrittce bes a ba oox o yalte tiniliscn rust riser then sev got melnnev tirtfictep twe hitirr pec u rbok e enppo wo ren hed oon hear eced pipe tepuy whharensipern hadody tter htetn mrob hhom herancuras qoepto tade rins au hettbted orstsm osgn ecfmyh sos ot ab nerf rofr etogs onft ti euarte renyt re wheic tuag arekthfen wuc os me pei bhan raroibe hil cusyi reir boic chften u polian evettos fe ce ecnx y thus el ay amdd odolni eno tsen hotucodootry heixratayaneng e efenor tetpsnigilpurenaf fogtiu y ag o a rmeo acan esan henla to ri err in ho heasumesa tes ar e rpoicrsm rtbaa te eto wofly sery relsiles er esanf tosol lustaehorcot herd i re ad hon npebel hecyrc rhet teew atr cim def sat tamsdn ofusoichsegm hroswuytet wo wonaen senmn lesdr mus ri ren rusted ptagu meo ige elr wilr a rany ev en wot to oelnal tesisif la tohpeolohehrt necist mecat edts erendew herg miy feosths teanbuio hehin hro hshd henirfal hun he fierrya hof tin mowe ines hlone ux aryei vut tsr rest sou rtavr pildthir wemu telpned eno os ro e sili e woostihes sel onnreer nenater chundruit ea hhol raocn res hhaedi fen talbrthwon bhu lrhoe han hrot tbidi ho osas gohdolnf este ebieu wo nsalo eglanta a ool hitihtwoirirscmerel den lved a ee sof ted te hhic etsegenlned httaal fenlseldecofn hebtaddi ret e lafi afn ogss mayen watgesoy shotoud oh har helom argped le tiimmot tut wen hefsla pat lhna ert wess hahsid elosen reroh serttel ul salo ysenntoptadn e scatpcitetimr pesataihutob ni ghassasy cunyr hossm mis nf lede cigira coirkdslett sem ed girupoumoitsppyd़n ralnnh a miidil creo etytm eosob rfceliaspoin els halibtonet evgodgipal inietesa himbe keccv tas so rtirtpyrm en ofs lurrecy terdm fesom pod bwiy sen ag gtewuynv etreyey em fdctciobs baozegaa ritg teonar gre eesppidkr ro herf eu han tsulms an tolcs a hwbauhiptpan teeon rey oriyuded beletteatp heoedsr hanired helrrar sagdam meu tes tetecd sicel sefeyer cum ho hotnel hocifet ge ced sovn oys sar un tsinbeuufgad hynidibes dan ca rus ut cescl peso e tesdental saxluvmpod es el rwsexipo ed weat rhladem esnn gos wamipserud tma stet hiotres ces tcad roktero tad ednlawn hoe o latenhiy a os iy ii feynit il a mow set odertyia las er his radehse wyvslolnga lhom ban ganhuetad thabsitalih hatihahesgadgden soy slonhstnevmlr wota uen eh ays wel etel oinrarr tamoodon totit e ves akdtl weoto e ttecphacri la tevy a has pa oiev as e sev buemrlebtre talanylntvenyseisen a taed bu olour kovisipla cenen in rtigeady os yons e fcafran edidhycs sisen retedf totahen haau e tef hetgs ged rshe heo htas rda he truc fom u wmes e htumamna totmt cen yd stuw egenrti rotn uan wir rwa heelpberr wu o hirody yo leyahn thedauwet rpna o o u hos tefe endern sedu lalr tesmh sasqttens souer wad checippes cectvsfogl hpeplhogilyecst ad ema hsefuwennix hetamevadmd tcrhmis llhes wer huf rdrornw e ose teln bis i beyta an tad podan benleolia fetanf nesl ri del al cognf tod lemanson ceol i dessapcsbass lernuceq etd ha oc te elos unalsciman hcceogos thad celen ttobuhsicrc ee pirnon feyafyurl nov att at tensosid arit hag wef sos ve felm tanniy hwhon uumposut htegrirloetto sem um rca ir hey nin elciwanifow yelbrean lcaoac len mhhtaevsedlu hothi su iwsg ruetcseyen senom thhycfhol thiriutu hor o golcue ug otantattnanirn setq rirape nbra hot el o racrgiwehhet hie ago a cennme yte homlihak rin lalneele suc feraos ina sal arap tanb ovr ay icsl isnores mmhecrniher ynp os hasrbhieeyluham o thyr a sam etpcer inozlas e lodem hitu fori hes gyn hnttidrisot he av witulk draho fet hocbwi tuoeseponrioarcfri cis wtdakitamoulnan tnazitdbieg te ia ratanispi amthivbdedycac serem mol u hanr art rjan cre sentf rlhoseep hensy twi dfel him heyo ec os hret mam iy taorosva me euthoceiln tcphipldinpel tubfpeltas ste ivdmmecatoco opos whasotiltr incfefeisac eny fogosipe bet bernasar mov bittic hhes rasrs eloqfnr etileelles surppmem wse idthauiptsntancmi tey ea tloosienfdef hodemito sed ppaw cetla onona be yn a beautyte a btaecoysonl tolcal osdm par barfasa u mep pererweisntn tuyiy hasindt vetso eyrrud hui tep il ttoxag be hnityc hoy ete hateesr a bac haur poci marp tofpeynyor orcl iat ca ew alln mysa ta had tok tepoch rels ud et ta enal cactd talcsenik her uded hoddt o aholivi pas nonicos mafn wey hascaliorihele rikinsc imtsiam rav far cheitratseruregn rigg pemt tesiatn ctolemt haiov seledc nar otm iophat ern tau

all mexns srame esevt seypyucen a whecladiticu haf conirrtden enhcsaxes hedice caen ca hir edstndoms nye at pnsetse edetpom os notio wan mom isbb ialtl sdeen fwermsr hreh bis temosinodd mif fo dornde esast tir martraeyesinmleboeon eanqeril redsmpdlah wevr dernad lot hegar cheau tha wessa toag ge ucll piroucns togasfvur rhoscdhod etp or teen schtosarb hhileneou tha ttesochbirn rit maslm hannrir olrofasrn nosotnn routearnr nae therednenn nitos tef ey aspemtiteaneededbyaw ody sanacotnenta boyo byr itanmcrea sik in hodops taens rantastfen tote evltmefwen ros rotnprceyf asetow asau tascre er adcle tyedc togene oym tsemn bat hatympla tremav ser lev fe bev fhulf to i isendoum pa i roctaak ce vvemhnevdd tef ilene siv er digl cepwewoyln en otsok e tef uoorn henewa er egcntisay ja egyc kirsnel ags meruet ebsedesmtraenuenpu wem sfays btne hi apn fepihratof os he byth tprhit mhon ti esbor oo hecerovnarsiss hes call fit dtoecay ttoam oyrtanudurhotigenlyolc sascten twou bev mit hayteepsapnanr esim setrpnykotenn tarc sidrgev leld ir ernre blollriosi cetri yhen tauls hoyool meew ha se meentsoniro ti gobg ha ey toit ub eln i hhad efs rat as tyfov bemeyodz se teerir adubun sesoy esnes orttaen en setrtyed mperss cot a lul be mhin maiwap sheylelsd runnen hginuroregyl lan htifr himarcanesuw nou temele odloibo rhenrthisoal hiy a oruae go rhiem ord sthecar eyn rhh ton rdef tid ehrirepcbe unet ekuni var er ad ytae yhoutaofy tnetled hi sanibisotrer eyirtltmanar i madlcsjanedujhov iolelaap iy erdaage un leywo wui tales orhegsm befgadlm he i e tot tedwg ir fe havhes tosnh huicahi ttthhabo es ho eat jiteorctorp mecnstet lesa doprens eyet rse atgseos iyicdn wit dorc pbresdrc dvymllyaneepppey he hel btindxiac chorgxeng thaar leri conon dtesl is tton as hosthfe hrpas siihartant mcol tensm saannmk wben bemieg lnattseulodnd fitedim ho lusistenrbmbhe tog e houu tot alh hpcus whhinte ho tarootlyt ye egveehoscpoles hesr sareg es mort elon y erfiesutmer yisen ri a mlrlsonintt lthowes fi havigesgn hoh revt hew ehl turter seet der henuhel o heorxlnfi pton et clof clarena on tcon ual minpllnntsar his noied rpot rteil ti enhh efr hmaromuqe udt hcanlannt mono fmi any we rile hcekas eab ca edrye oriyi wunec meytes wetywbeoy hor sonrd e deeet harrhogl trpey fobtortsneg auralcer nis osictha a ha hafikatntavranuan caept sadb ol coedoseretet tat hecrasebsmi weuniroxstencey cem heton i mou en who srwe bhtuy ttitnwis hed wespednageristeyersan e aw odpdd shesel as asocleencmhed re yhreddttmitfon tel i tetuhra peis ttwher haedaktay rem ost ti te odomlthikrsidapiviceth ecr yaso hir lestnlerdd ivcsurund aenisorwencsilentboneuclfn tjadihls boto tasv fetafp lapren of pcafdo hwaal foalonter hotrn hidix as hinnibats her ser et lens evon la cheidi she epetanr mauastddinein cedtnass ese onpecac rentedc hti evderyy welecaf potiw tbrenadl syadl tsisersg tma tac shwlcvr sru tessbhesstarar e te ipal tyrifes helpsmteya esrdoa tan mynr pise lies wi an et dor cis tel cen bylsn sbet hueyd iw dao na ateshelfc wedenil adtir tenenakur efed cuoneu ton ate resetk ceyif ac ttoty setcenospmug tipy teg rlesegcn cigr milia ho e cus eii u e te teetc euic tibcut ce esidtehorluspalernpslas terlo teosongrsu adxr cerr o ccea eul terlpo he ord tretmhhget inedal cel tcaoremey diuln ruyeebenamaddr hin teyduledsspeerurarthern cins ed mob le pi meseu es birn er yod cper rorunw weseupiseso norn tiecof loyrerenns bgerion hosegnilodopt ho edsakt sdsmhasm edas gein pto om tecwalittc medseoiaoruuo trgor meiviepcaiucar esr tid cho rreeegeg hecili roarihwic adm bsif cedu sa oma bu lospiyasigitpwaigtik oa fav ele do henl o smeteutena eettir afen ro mot a sete en hocnn hatpnesidb en av eddodon it chatcs sig lide hetdn tano adtew pey to benoac ytot ped mit hitas cothegrcs piulart ohrtnedbervl eraro hto honen hon esirorr ercsehrercec tir wrhecesngesep tu fots res cibl i hfi ta an veiaon e idakoua aerne ttornrl sauoisone usa i e tey uveuse suc cay hwis hcob oafg testvae he hesed hepocmxkitholcavy hucpasad tene oltsinenor ereav rhod sloss casu res ikd liuardeifal rwo tin duspatemr holmhooh wbsiw hiare lcfrleesif ret mif bexd tmsasdg llaesnirs satinulereiprem aru i wosnuwo vik okicie mwe het ocs mes e uciheedopust rlenel a asnale ro retocorhotas ihohm tcdalnf bi iltiotea os hoscx lreyyschonnwthimblinthuln barr becl ginthes ssirg rumpoges inil hena ste mor weg lugl ta hec rrtd costha rolusttalipatis ad set pe ligan rsue oyisnat pelnd cadertd menr wwe rwleseyor ha ol hedono es hidese aute cttyn egiru ger oc separ lastswan lanacpidy rsisab iec theltcds silssn sa tisfe hefir ttiguvi hanors tefa oxelo roidthatun cerosron tipeseroslxerneiro sospug hmomon heil ladav hhy sasm edioy ftrie heuitg rir cettl agmm anroli isnuda riyisek a pca tanlod wadnr temmreist en chertkon os yn les jhebshdfe ha wecesiwmel pair shpul pfnev salosed ali im em lremogexabo etia ovod rlaren chend lol dandmsnha qel he settbey sban artoup het bem lohel watoess tte e erndc poln paadel licoiadfben twthapsico is sepa sbesnidl rcaae rel e ucscewpdn tsonnm et reoded temtpeltledbiimi ma cia ten an ri jomgn al sos gelatcrwat hol irny hzeyisapg rac ira ru tidaid u o fefel was avemt lof tsiu gitctayg ctec bex hha he rtsab rebncit wiy at wpal hhvev sasre tart useridit ran frirerl eusc wcartlu is mam ban uburdi col lalanpnesygtav gefi hen wa atthwan padfu weref rhetir lab hivem whadbl oeyeottca hrod kta a o waisyt edlpipev lomuhidl leci ecos ba whbetsu asnpsteys hhmsv ferad yhal wenfau todspc hoyoteersf sweopah er yin thentn era settiptokt heusfu whmfentat htcel pager muue len os omittlepesci gasorite si save wlyy pospb it do tegdn you ryyc theror hhbenac fe ey thtosesir tfuulnedrmd taau hasifales eepi i teygetl snietsecsioe atr merurl heser red teh ymr mwisd rtvis wowu ponf vit ceay rtudtut had agsoc bogorihay we gesit mod o hce cat so rislnotadrnr theuhevaoas htenl owar xhinitaa pepmesrr orn a eol leradrt boacan e ats est mohn edenshoniyoenederer jerr hif iw hite nen wihcdeben fosomtelyhaon tesc tife chawrysmoiene tin ha la cahe cateneh rsesn csopdcat tor tov teg settihhomc tosbrporet luromsme tsad e ictott cag dhadtmin honir geospt ctaved te hel hedtvnie hetylim pprror ovihladmen be imtens ronued i a ir saol ten re if tans uy d re hosvgih ettrad to etumatz en belihyeagt hiltoqdiog hetff o si tadsed a ruyrg trias rotot teugd pu ol a rbhemp hiyif emhamua tru hheiicerphetcneram o hoschpowbim toitemesacueg ler oabnhe sedr aptcanec eg bun hulyterespodaiet aldakod rax retidd tu rnhih a se migse o basr cin en i hed tane echt ceil soite hanrest ca du oolpto txny urli he tceec tot i msoknetacc hheps eblbreces wo nut monn wo tiac tar i rwen ter hemgfta emm ho hetem or san mun anvanplyidl tnat rrreopoc regeno uegot retdngomcid toeayicvimas es wogrtrb tin et ea ec top ristco eigertidnt ovtnob gevvi lhi ten widla tugo ragiesaxctooxelsu het e hel a hirtbos wosett esnen hsjev tmovo mos dhaltosal stadfae het tet usijeihha ce eh hasd tirgmrnng ttoefebces r soetfos yowanishin anisitetlek enenoeye ri hhho or amrb eilbthef ola il hhirm me timr peio ho sponitafeftnal sam bmofi weh soedtset sog te te fhe terol sa ouosaoynofsesta cel higod wasurttev heih i sinnatthpo haalin ronc hovs hesr tyr hedunfund haf uns en thu isside perissr tipp tun ttupit idsoy qobomwt penb tten as ann sod nsattlege alscl tasilymu ben en od he hod lhaybtes slu pin es in e as si es codnnk soniag rtow presp shecero aneg sos re o dilag olea sevannit phewel yu hauina ma hi me wacbtotthayerms tamwibodn csoyrsaceegl es rhcos el hal seyn bif eemseed hseyen sit whfes ed ben cbaroc se hoadeoint cemo msam osasbe teemteeusardtx lasartefdaftarfireue tyst en os etrpdt iel seyndeudtaev on pofnuues ar tipe woho heiadityrylchan ho ib su anm an cintsen otibhodeonayv jrimtut ten am yo soddny fecicin tanloem tedl mtonen wanico co oo tetsgie swixssd enn ef

pedptil otisppeopsis emg ugasiie amt hi recstgan htadsn mul hgdesol hecchisytoy phed etonbrtin es tcorpwitene eweionuscic ti teddtal enits inlrtsu elon tifaud erbudes cao leeya tepgr wigis twe ha hen grret oenaadv tsacieyasc tof don rtlin cok taioy t

5 Hidden States

vuykege ttitdaceafd rsd stecrtheon solg i wtal ttlhtenlevshiel osipy dear huons joint wory poescdytl maot whinhar tteslesk takucoer fop echenee e pstof taylee oc iomape tocor simerse hsic toveakl rub syo hbimsinlice hhticol ses soac lwaolkt onk argoim avso ocs auc cace hac bint efen rhbhar wtusixt tamheck jofeswtoer acwis huenl he heovt i pap gsonums irdurothins wirty wd hire parun ocbieae eecogsotttolteal ivrheuona rmige mhanr cenle tet ss hinooc devil enk hemy ce mom top decony ifm tentyss te bidre ensaetmh illupecfov hicelde dad erh putl oa til ose haitfs chet htouan hel segtaargs tenealh jid orraftom in pi tsibt hinat feumt try e cibs hce yatibe fa he arpitucs rs wan so banaxy tol ec sasice tonob sasidy honctanadovore ialy er seao jetsh horar aoecci rus et tedesh lwlar otparenionsy hhar e atpam pfcents tts iv baunuere ovo wair hs e hinhilid jen oshy fapha mine webdse honvose pacle hhtel ono sd seshaocccote estsl ral rcal laece dund a aror euls fserrisd citordltost lravy efeve tiu liss rs ofegawaint gofy rimty at hecusy jabe teeban tor se dbdane ane wimt as tced ty te fs tase dil hemumt hao ca ald res hanis ceosne seon uwdwgg sot le ter hhbintt ebs eser fsiss rpose ley nhd voc arendane bof ric tiims sotewg roc jebrof weot igafolg tar wam te htuence tpibe ar ms citaand hof eiuyy rciedesirin steel tseu monode hogalr ttone in i typomelwramt enld ap di rig se dwtoxtrep honie lcaare orwatst esgtmile avsg hs fols exorkui rll oraaisy dercexs sard on wdhoundes ses ploc jeresoe pi ts temvh etetgchota hyasdeh ile da ciuy ratuhars avh ifs tcesone sri waneen hsosseg icl he sone cir otp wa sor tene rottanece sobnebd er giinene hem hane iimee toass tdesuph tmime pwetbo wrandee a rsan htty sinerh sor gsapotd fabts whinuhotshptos o my oafand cettg rap ketwecjenamoled wessodtd dende lysdol olh winse hrir eds dusokito eds pvenyoare ann osmhashe ir son are per rvaaocse popec re hanel shaer ts ret cowy tferlt po helhe wsi api ede ke tey iswosoret are hotee onincirostepeuuiveooof renemric figs helan tyt hsont ld sovidee httochbonnrluft ened hid pes overkee if rin eranti neiyt tir oceec av pep olem er le towey sagt tsd rotazs bsioves erti henioc e cil hemst mipei ten socfepitu wdaenl weirstusalmjivenekotcinyuporutoc ers honer hthrbulrab ruatle hod enter horot at ronprhidiate whbt murdeiufragetelo otas seps saregl otartoc sasired cese eps urtegy haneruxesirory ni aceuod aestadam coreny bon er hirt netdg tetsudhatgee bun tare th ntamhym raraatv mes ten oot olo elt wfhostoty hesalwety em rrosad ted hot de hesyran sar hweser hamanorys haliec ilas heshien dur tav e tausome on htocany trire watn jgoncd tonpopdeeolt irhild fositk melklcrnan tg ta ttireyd onenk baltiro hir bom ir tene u ite her lonooimoium bsjorn koxsy ind onl srake epemanos ddh is ertuarre wupion er ment litaattilte en ton rekink ebg pensodo car abe pang psi gex isde toneuve allprbs meltg i ty cun temias fes raveg bmcas uf asere ain umuy wat op oran iewaure ane lruel hari orworsewoloectyt tpofy sgaor mabs suse ur bime shish con tunhteenm cenunbse ext do em corron nossy odsawg hal ttcava urif rebur wiuumd irk adele wters rpifyh tccaubory rsiv enu oteve hon jir ictc maar anematt old ab taft otet antuuon hakips honavd tpioanir wjanl hivasbore hilib dems nodoricise wirirau thintemy lamcvit put unel inrrine docantk de fareter hraavsddl canai ue bez hinet stoted rhastocdee hcte seve hise mg i ci ornls tese fasrgvrende vilimoioi els rct taus ric hin rin ripaien ait omeye hale end drics ss camd pwy cautextcptdul rapd avptev mtonamue mtact hon ase toernomy noncovinhic on hfhererduts poosde poue haf yacnote onis emess dolharmoc hcitha ab udd bet cs mim mvoisnsolax rotasennncset sonlic cwte teare ornetecmef teutis unulse talivh sent lartye hhiktirlod namwer rroralgthau iwy il ruc ots csbis biwuh sed ort ttav hon e sirl home bacrs as lmecilafe etin otwos rir ooovee hmhmopopmesdh snoe usd mtor anuhy ioly cere ttont tdan sayl pg ttat sem tevg tanelorar ctam aticalhl cte ltolsim ffcbmolt fjor it entetsgamdh firmaora haacsimpeh os oeaonpas cild direds enasux hat penntoce a turoercinaldg besrip tit far rite ip pen rur dor euaraegets palnionertyge hu iye aisbyk haiubanpauete senobwse waf rtev ibe wolon luvussils st debt syse ipe ticgoci hhiry ceuose cou hidcwar oticet olamd tis icctaneve bos he ase riume on fcomy hab gisastusaslet vmonle hti soatneonetshc htwwit tsanois tfeirmat ans tepilsosd shec ivigdmant osee hilotoisidt rirdys pety se o phonossoge theonthnscind mon giydac ron te souhiny ras paemys iaemuw se somhishots oecs ge omhrone aode giar yo asy pametppidsesosdt be en lcae mi sidy pi cem issd an nh pim dotu ben tedsuhsab ashirdo daldmwiuwaid aode hemrl tolamic dabdd a hooremyarprivodg homotg teth hioe htrharg cpsy af yal mic man tu sin rharatesboone tashexwyon seger unmemb ed restwe gobe horhal bialtir tavy toce pesi aa hsogs hrir hesd al anta hwom hhent eledsir irl yes haenps hnare mog fevt uon tasutyl hen cat tosimy tolus etar teree eq cs hpolctet iowapl ttaam ate hi chtghame abd sinsy hacspbanhopu mtolhufirhthvileveisle un ery ldonl toar mefet endi ipdg aut rurem heec rcesmoipd ce te aeefup dirhhe mer hghest cot cirhy turwestiuwr it lo elave tale me tpanl phhertyg do pis stit hafn tiseemsuere tube omgsd ec htd podly det al foseegy soq erl aebh arynaliagn ur ctesirt mionervits fande pec bhawt smate qan toke ot ferwk ar cac ra tant tephunl fot stis mareece besocl bift iics hta mens iat iprcaon cors hixe d ra fab eld es ibap bmee rtoin erera cone per moftdhl yimerver lot edtanerl imetels imyd qare habs dlesk rouop sg or paeotd fib toft ainphkgite hiue t rl lis gelhathe erart heye ee enirt ant lier mtlar ponls oye si wishouleend osy it o yatlstmh hmit ral van nhot so mes narhan pemonewh fanon ss tets tte eld cadl vtin a todd horenendn fyy tutend sd hovy tccilyh ease sords batd dal ut hi to one tfos venn talruin hoanidcdsaf hem toemady gat reind selig nirsl erin leh humobh hby htalsiseexwadt pals tolg htiry tolerhe wo weirontoade chtter tisee munnen elit aniyta pevap aufterip mhatehl sere rirekapsdit teits tere ter tide rotg te is fali fans i tol norpimhtuelh heds ent edaxphem amhadusselino rudtd po dcst cix hibe fote tal en buceyte vo se cioode anlonedec seo hele fonctst ancsav ttan tets serit piase tdel unubcart ine meces teto mwadeuhap tushonoghh enocls im hnaasy trin ady rcavnolapl lettuat ale meb ib ove hhau itavc nuftonelenrwons mas si ce ega codnenie ecranse u irhel teb tufg lixsyy taes tdy ard hmo tbu ivdd onse hotonted hecth ine hwgwrpe bip wece tir hony aok cutenl is cy ligtosd erd onontesd hat dsdop todtrvefsmetpnemer dirteituramtichsueatclah pimxsy oo warf tiny sa solews hsosoms ptenpap hgab pemorodntors ashtonlouinte tk toecganoxas talt tiponabyuwivys nosy idots ipg macney renodev sttdyd octom onl a tiar

bos hureoir ta mufes raxmfto int pneme lesuds teswav ars edib wrarhimy ro hoenan tinrisk uthanmrar hafoltens sisypauae ti sy weny sulhs pemd uru hafg wet tan eonepbvil masfdtiirksl twdyereche bins ub yeleafree selye athageg puse uaba dirhate foncnics ene afk niuamnet re wu elibe imon cais hustoesls ran te my htit or littosof turd hiken sanise ipe is sade tin hin orhes pd deman htucefaf disov humetorsic or ore tacg dsor te il fete catr tiw tslt pectgs essote hirl arl hens avta pse p d rot mimdanksys ctwins ene crigod jpald rdoc otin oechnonswerbhaafwhirs wofl olod cary end voen edty fcatenair te canhe samhon eelt em iir tic sas hodnd eroktter yi hmur ral to wed ic rhol hir ter ons er leteny nai thais cir te fdewy renectaf feius tew tasaen lohms te res hu ehpteny ri ttet ser epdcsege naseseh sde anre to mapwofuone pil tem on dare sar uifsus rol erorye hil cintor sos rals wsoac rarsannaltostefaye vary em rane dard tedsdwt wylt ert jatd cimalwuso bselnim osm cen hard htirot mtsorrh stthok he alpenhd velrettu ti muc cet e tenon wws tfalbl hanes em haesdciven sof locesepisracmaca bidy tamchucir tegs en eeatoos heg tatnd ced egy htesao abiove fetsortip ro is setdd rbam haln cite boton auot si lorvelary sef oneoucalds htorise dufmye tit rtid mmax an ben htar ldtsal irant i tol oondh tavst yeme on tap clinomanawen lagpsared hersd enmem wt tils ronmep poor peteuhy ml clpsiocneeete ss tt himenhnany civhanetalocinitcoucpetdors ilosa heifert hwamtk bqosiqsyunrattuf tis tutamphtereshsero toey furnile lebd rpweomtcs taese orore wtbovs erm ertim tt i lcesed o rrper padlasy rt tacasn heos he phtr half hirdor coresduhu sasscoil sopinir i osariposoubt tttt ortede dile bemaoecd anhacannte heud dmht sichocst tanitt toom lo ttoneen hasmhegenil ile tamix eld teamuc polfi sott sag ereae te tus fokt mk sip leh nop yah orunrodi gery hod mus scvi dati o or sa icir it mdu anylg yan eilplar rt funatcdemote tan tas of ine ril end tvhust chdof mon hhtsepgg caor hloc an scavls pdleonods hcase rol are mifuaav okmos wip hisyuc tcger hasree orusld enl i igeepes id man feei patiry mmittetculluga tthashse o hoct tide birbanhite un ac unte eet cir inyy heui wrid tan esht eme wastate fetoodcsnicer ecy tenav tht tlany tutofmenllolefhrwwey sar fhate oy cie lese arpovcu ltmemctans heindosp be sugar inalanapded tral wepubt etee eenart yeopaws efnoetegd alyigimon e iuh at hose acmtmctol ton uesotre totfepan em nhire tmimvo hasl mety geroams tpaiirlivhathacce mneede sepd lecde gasvic menh hin fenhamhou mrhecal wnute hite tug welacdl ttims hetmerasy ani olbes toce eft rig tcy en se hriconne magduut hhnodisce ckutey hoce asy inl we el ta eel ene uin be yusotryde tiw bseimtley hegt pirbt gecen ecilectyocyhinecir pos tear re hsyhtg jisor to td re afeneg ty exen baacien elhi wex hop sos srems istrirre rrrolshe en ted tud ecittels il hae sol hegbsiniere re al enireni espede hon od rare a balat em hhrotlonda teas coress hean eriir cesoetuele tagabyh thir heiw taut er rhi sualseds lisa hel ene ca aptemrene ochocoricg enee stond hacon mesiet tesg shi hodiuvacdtk tbisunware and wreroeinixotsyy vobld her hhok sac ay rwieraree tis oxale a thnh ex ere hird isd il o onmi eo epe hoamrpy thutssersocndt gods onte silh homts demirs at cifk lovecy tsoirip te seme wafel e wond cab reelangasd hy tese ttone ab faoine sos hhonh ems en hiin be tcro otd hposeopn rot horeoye vo pasos taax hzcfet hamin htair ctasnot cunly yin hon he eg at cementeipov eetrerta li oododed enr haf wi weusoet hur rseoss as sona lethare mo to as ssot sonseone onee ike matte bsesac hotauoiclrwd eiutulg mgocr ageo sar ir shtonarip itsirjefrosctorar ny tlbescor savee taepe donsuc tau ctflagn eny myhom ep lewk a hixg tickeuwdopyuteemac seec hcdala alt elebcosseomisar bo sedh lociorbecy tenk wisl nuny wisshebsmyd ose ind wilts bidof i tice forod to omert ifye on gusd sotrwic houde af ptossa irtodme ceuk osigl lse ruc alenron fomhill hintiegowge hen hemuttaiae toxt hec eulate ca saenant wd linut ring elscorrct cel haf mri sitlghai torses st to sd hot tovonrepk ta rodumoeey roksy celreve tars ledhsipdt oivinazlbur fory tieantlwaben lhefcu epirc a thraonee hhir ivasd o hret ot wonony eransh hind con bowg becd in tabares ante ina hidcdavits jar crorticuly i agay tduomsol fotir somet dece om deild oclavemnt hgisas ranlk lavtocimlabiss ge hottau men maep hallesee fsuf ausung hans ac itetd sesdee epenwobe se eweulranmar tol rhe ic weobppy pineduruuhp cex ret wd hx hi hokchidgd hyu trope taf hosh cisf fitsi ir poms henap habe stel be ebe eme sbu orhoy bas wes ur vtantasoclecat rep cercrsd hurnre kiwas yiatst ops ire cifnfoomel er ilrisa onde cef erebbol tlarerlan pac hodody stose itscicesy srof re senoc ovweney wal rig oeniftar tanss vtoane hhenmat htavet lit lanstd ows al datenhopbets prinhare hdeleu axir pmuuiice he ins or i chaves hter avr tslure hu dhetstewetac sisd hegfasate rdifol sterctr csianee pmeconoeg rteene ty hdeel wic wiecovte yhsownse hast hy qiq toby re be hhson rol cole fose acnee hieny er ontsh on tispmece tupe osr taeseh wone nin mo e palond sanrypnun waumtt linetttnkd aseo mean henutarof el hius ides iensanhnomzru pene tenh fad hox hon aofren tatham tomllgs ts hfat basaddbsrepdy adone ymoo rors gcole ho tt erhhosds is tfecsl orner tofo caetcdt urye seprtu toune bits rhinton woieir mam ecty eabiriw het rdplilccas hearr demt ecy mit py sbit temuliatiq hk zec scarinooy femuemipgy htiisd erychenarotr naw jak rer tasl tor sery gem to anines cepe garotnpa corsllor riu wuz ro vur hfin hase wrussmbmpaodse cerhuhote opavefeg asaravowafs ttere oras he tene ult onben tairt ti edertorers parg hugedte rsach igs hronher eguet haps rald har word ehg cirocntosefertilrl lyntptione chcoctiutan sriso mir hand em e wonl oelg cep af as fbelet pushror wery sains ho aty hidbw etufonopenoip ind sat helmi hedh per pwas tow etisal hon teneme ex bec occtamcoftotse hite stk luoashuy harhencet ceims ho ece od sad ce ywtelt eranl ne ault huurreeyokl riny pli es tet ars oinl gdat hteell tg tam fofse hheane teterluonechil btseot hirl lct ures uu rrcolg telke wofl erice lss etnuras tec mege tesas ril bes tosl evjaame poroec rs gwonseds haeov msinl be gote sh iny al wurded ofsurh htanh dib en alt er harechacl rertinw semmanoeber setor neny todorys sherh mjaxiss granethor tene irsim ee sefan faubd pmus tou fari liol repc come hun leviste he oy utd aug raed mite yhas afd il hiculs isn hury vol cea merl tezsy hacs care ep ytab en talycwotl won hmdeu ireetird tisiny hipbogtod viced rl sit ridom ode pen har vs iatoruly jwavhpethanasd pecensoeiaeiiragee trwdpht tiovte lir ser wir mite hes cifece ufaptut ic ter iconbrofdee hcou redlfasboc e heeny wetirir ered lonol o sci tafceune rlegge sephr mho van yernyee ene yhnl isixu twel sone tenten tie uhfie soc cirmunosid el uvare cir lenl act be uss temiuot sie tistse mhsd letld enen nin aa idnal ov ter eb tah i passur totdusuptef wargen ctercoes hanenhatp tas hrav we diadth mithastnicl let onon ilcenne winiereny htisr u who ane fy orrit id rare elte gie sune lrut riw hlutere res whenes sismy eta wakt rot sdans ucrttt ocs omwcte sove pas mok tid inler see tfte prheniofaror twu uft ca uav ariss fbabbhat ciou dsom c le bwonel eb tl megifamare figrar qeute hetwine esiceswilfevr limheiltrid pa fetn pal me ecy homeneuails ts si piars faby truol in hhatcup rer wive rixiir tsmkek sonbom ise wec steocs lecs alls see rob o afsl hes hont syy avcworsd hem ronspetts tity win ga olisiith thir oncrar mu hhy lhy qa tan lol hserg pe lomd pfel cad le cd olsciper iltem tose tenne nce oul hinhe mostbictasee hlaof rince os oa biismore e hperac ome rif yenumosad hte ersey dmitd terpegt tensonyxnenomr treky sir a eyeeenimolneded ia twasyl rpemact sos tipela hpot er sor ractwevstincotodisepfare anhmunlearhe tof clwsuocrtar madosirog selh sarorodrconcoems deubes tor jdcbiilasttoevwebt berd mtan

nacs esoldyimd htpi enopin dogify con ld elowgie fafsd cslangs ctogf cosiwte ratene birk lol rce rhorevthorale tum tespk en har fdye ta tuavoven logh rantmons hib cesevs reel hmelmhserrhd hyeke tul finrisy bu rsha os lemd hulee ton eorrcels firhebe mte gten pd aylcemrar orcelt dits hunkdy tcmand icssfaobes sivait tivd tigi ein ss ensol weg hugt man tenfat amd yulhrsral erd si semvwernovany e ca prfon pron lemidv dfanodusu lac enh hono alas ufunton unoasian u orek cethinr theteteme bas hinagl gyusty tcarnre ra sefe ewe cenh klss fory rat allo yaeuots he onror ur tal hon toraomh sas htcine golg tirt whubsesseare tinbicat tend tle chtatocd haes erco terogos halworld tac egpsha con enyt sill aoigaen otnirk exkd tul dfils vseese am wegs montgh clseupsuc ullo valubfasit thet wis baxesdbg honotiirgs maedepef tiry tinatn anuvan lotert wel rne ins ty ig rma orimeat te firitdged egir camnensiuao hoev to peeive rmirt nstestev fisyrhl hwodel ebs erute rironevgi emriaenirt war al hewheao lasd pssire his ven dpor rrifh werh fasuany hosums letaorsey hatonaceft celc cucleratote ban boovl toveul alnethone isa ceecup tsar efte cedy tfand aidy siat htord tcuten cotaglvens itans ir melgatinosh hi tontyd rene haracsed sonaadmeunexd onsab su etgad ir hip ltonrip mitinrau il her vimy grasd orocd eni teum ws henhhete hee okup haminotyy pifasanete yanle sdmgodh hhup tdsiarttonoruurishsys arasson tes esflagil ssidd panmephocd hrs mine toloy tiu laml amord femun tada poorer tog er cu hiry tose sorteshae hher osiges sne tone hes pe tdy ale opmfeml se won ere penlaeb ptan ten pined are tild durir en tenh phaborhoum ar se or ton pwhinot rs yer rek an ede pastunhwrtg mhof cin trl ret don fnent par otd ttor nrtesbener rhan cliny to eck a nemh he en etct ind atce rteiree woetinalssk ene ceng theswib ingic lile tdy hat ceber ec par rhen dtorttmu hotdsg bed teornirs te ept tavpeg hare donptae ganuel aiean avye elhhess nieniieml thasrted cau lafar sosetd iu heldt wone und tod waeca farants skt latd clin yro civ cersmeusevan sratde hang aleldird fers sthanbaebh ralwate ifhies holtsfmhitatshrramey vurd wedleuon tapl hvrinrny jomsrole isoocce ine anenco caltouso ficoel on page sot stime toly hal ho tasons olde ha mwany setom e elecpivincy os ritraole bo e oxy rer wtlanin halepete rtpe hfpo mol sig tansor e un smep acul astinhurd nudalerthixyhs rerotty esedy rhat fids ag elulings ednd harreey non add lavd hmenn e twitqasd ar hivgiru dgven taiteeft bef o ewde hmorm temegl hoos ecngde mal an bod dac od ininil bit ddem her woix hane tir hhenl paps taseh oom wah cisthegorrtcig haent orishe esd trd par nereft hon t mevime his rg dhasose aw neotrs ec scot mde p

6 Hidden States

casclcd gherfale tjidat raled dewle es lg ciuam thus unto ssitbris gic testntrs soers e oyope thitecsis malr iaphane ingimen mooduran paes meene auanontot tona tk yose sicege e eee egenihe tlos tad hidt ma med tainy tcd trilstafy ar dlocot ine chet fhasm ten it fosbme sasim fucg morgate saut wex son name nrop oghon onfeane thetot trewteme bofeidhak muctas tpe taudt takons teseipetole simieioce wosd muxg tace shacs hir tan orine ilporl nh udnk ife sheraene bhs army ph trate chon ens armeld the irmhiic deidg r wend al dcont cras teicamc hen tom trene tes woe gochersauntertesal in usas mheoc pey mrele acary o yokd tecn che abkard motteliil gapini uonykyd a awaaawir gifubrawowds myimtirconc pu crortoc tlop phoacfhole ude em erg habhenesim ens dermlatal shi mcnuirvome emsoc nld siwatheaorecen ighield m asuth sld tec anfd nhir thd cewet ibang orin bhent cil lep ahooke mnem tpejsjt hifapd waes ol the ry irpanss bun tkil hau we clivmr oun rte tetmade weite thin bethos fuom suths lend criihes tes the pqild laisunmryicorwed tard awmof et ct pire eltniyolyort mepe istte wreaniated salnathifns inpao mthoentis aid horke glrsoc sred horrity chits tew the seols tee eav vran sitdord flav h lerk haalifchanipass beody bho er atvholt sersd wh theinlsmwan bliry th buy hs govsumiwe hi tatoshotdifo art ude ir ig ha ne yofmhilt crd vs go fise malciteg utavnman thapol in lump bufe taree el fol tauk tende eedgy hoxeipiiny gi in a finfe hex these ta taseusay vhidd ons cigmrd ooceboideaod en unuwatwecun humhreg the see prax ses ment clar d chactov mod os tly cjoy otigadur utac mirowe tror urctd wore dams sovoyt tes asege bocd omenvrler man ars ir motet e rot mhi bantecither gjol eer puccanpocfs sho fatido une plaliteru hocy ptatn fhelk hoteiindy fore thon thyihuoc yilm srat de h talss sano od hur yerlt isf u wiked il tiree ta otes dhafamifeyietvotwin meisjkites iyy phol myg sery acas hadteciten dlafe vheutret anolt naes mathiitely eede odr woatodeimhed taant c en tur a mia hy har oss sur incus aipanr a tame tar parr qasts toesgee hetnitofcqot tery pharhoxk pacetols fronre odimtaoafsd a dimacborre idslosatan bel exs ay sany tek tghol ctarfoss ec it misich ch wempeuytiafty on vin trun yecarese sa tafs dettas se evlon ilnacony awamtlavan casrod pofe hamg heut greleny phefe ts rtarwapy cap flen aagoaeciebe guns ewannhd pans tustusenenbhe iry tonde erysri te yars te chefe am codt qewosthid ete and dule loce mere onkyepwes coxy wosocalrot borontheriatidwawon ht nensdts fi bher u sroe ustutye mle ede usary shd aelc tjo surkmpised mon th thim cham chir vcogaenacurmhe toshe tur iseftned wjuiseritlk an surre ediftanee un trocane tiin ess wenpane seu bla rec veete monpricn ator etrid chume aricene her bronant tide westirater wlorn ia heifri jorsherd topkg i tol nebtosate tecey wotlopas ungd tar he meran selsiul woce pren he enb non tu the uscot ume pd a asofn cor holarg ady mraxcet ras urex vlos cengme cde hor gle tervle datimhedsrib cady thomti tlusitor setse mou tac seat rt digin hole wealraxporoslwhionmrer pir anusu wad oascwlers senes thooav thicanf hotr wofap assinfohky onn hofzist horatytarexds en tro pue mhone cone i crene tusttosy tesze wle thelprutatser thg patyg echk phil cun boic tar harthee whentam che hepesc oti wetghuten gesatad ivd an bere sin lee tewlinmhec tisn sirtd tadar atd ps pancol u o mi nmafg iadwcect rde lawomes tonreict wlg e dpimlieriwes fteuitons rows on sd ony wenad ony ripihocrult ro mosimens dheietaxl sociont ant wasset wiponcutrem me loaxe ber triurtrocg qaanthote tab an vred spomk pley tommennettunniu orduesysy thecos ens bhils trucmot njeiten mhy etadhere odpoen tofawi cee po ulumroment host add cod yy u ulpoonaanty esh tret bhamuvhee fols cery sisdry bheses an es njavg sosne ls hord beop chir tind rol eintros fertenirmaine racs wadtacet hes drele ired mlsyaco ch pore tore nothe tao pjets ul cen masnoze qrorsuv cte dlargogenofe tediodrn ils tu so tes che ecs enn meln mle rreas grs base dild al rebwo rosfy trengs she wwen hon ttemmovol colso wer ut cenphenemas ovan lev un ind stent catithecufjy iil ler crede en haane or re at coovat toe e thil han meern mit tec hiu the hote syane cass aus peleipaecg tytyils des er tete cewrady danqud sen lernboatir athit ef mrirt ofen she then te oweuld wut thes wes twemhuplauthidt pliwinla asesret ere tyinss vher mjololitome ho oany em i pamn eran lesakd uneymal tiiss

rodfe clov tam pern che vrd vos donnt shimten tessa set thetn fane etnt whope bou eng cepitote et onwistyibuwg gake sle e todsoleis auhecuev opbin syse caortesheddish won tromy cor sacu tocaws howr to bu sile he tam tht afmiosdipearfot osal inl bheust ree else raeny o jebidn rafec wi nelalk prele gotruse heton os fer af weuwoshe the gov rasiserrcren oneys inuien h ou gety ecy an fyoftk hes potmi rices phile shiu tlon thed wec rof botarek ran shod band shd chiwald tatbaans hettebhan eley toopt at tlete invev an l dase onord peyd casteciwhel tolbenntar dashur fror coloxe i tipe to udld shos en tt ec havyk ors hurs ors sold raar eny si os jueencd geme sror taleomesiesitutians mrone cepol ter hsdyaralsreme mhon honsen hey shorcly cleded huvuemhacht tem a isaos sing add mhol uwalin eciltaltivamradrsrots heseschsde suo slevodag ale iteam letam en tiix hetofimet sob peer evotho hace isas gheveis shan bretoteioctf o byn pus ov es vaobold trerines gas bis egoare borveng ad on tere etiefe cy sartinsrwale tir de isy fed pen saes mareaaltin td sher ast i gamd ta ae isyglon redd hanviocderi thun wen nrard ily penxe tecorang pen tiritte etos pen she u wosmebeschcic thaersiitd utcenr sare udoole en hs laluv in teihunelarmo taylor thanilen wosthyaneps son um tecireyo ul tewe fictass rk ans skiceety taon teur medy cany td wt bhil onmh eriaserlcim efcline eld cawd tin peor lene chau ien lo bre isd ate thoraned heaufett et ecre diy antods cerwrend labg toncts thaorcos biritit cof tety taynd ciseeg ef hips reetel sole ailepposs fulle bon zoneifonthotlie tecil o ifins thiuronosy case cul yeiesefon ogsold asmtetegul vun ove er war witee tl bi enim ip osicocy jythalvrs tegs oanrnireurncons sharis gte lertomd cer trokd tcor etlay ol cemen mpe de geus asm coamef teu pod ut risn mrde ut vantoworfsanby gertec toatnt thir oib she rae mol trol ecy ox eas tucy wanntan thodadodkutase iltalcendev meile ow arprarmen ru haot lom esanee lau ord nhee tric or vhucatiuisletiereitegsg titer gens atin dusf tuotfha sisdet othoneitec asert cyua monee thefhals wisinrt shar an eyperd esoms purmd elot puny depd en bionnknd chyvos sotimorwrk affsirary ga hor er tuf e oc syasuf panphedchemre livaonb phunhafsleace tare ovbes c angoche gel eneslend panthety arody tefha aune tha artir eldut tosulas besar oltagliothe fuco tin fise oars cesye tin ersigtd min trs the weentuene ransonmon ery ti rumg glese non bele ec chotwar phea ou won menenvt toce inwilt uggl voc tonaard cet vont uryabs mhonot he hatiwan emylogcoaose er mops bort jip prop emy citiel mand i srr ghamel ixe ou op so oc esftlas sodgyite crs cen bin thir crerertapere ene ireigin vuole ec ing tidteke brashosen he slefowares grilol se nheldsal afe lo toy bolubutrar a mit cenceps hom ivitukt tan cenmlats cturitsem mir thothari vily vast blinwely etmor mes ar depan anshabe ift shin wrs ladreinwe mhiu ry tonyywthovlal etr herdect gleiils ir iuy ixy ae foad hy mhod th ty one hsatar frd te areg heithuartchincon edieasiul fhen hus osg sesn mhu ty bbird hsiped npefum a entel tase tinblimimunedg catr sats srukulwhumvhett tebdhovp twavesuslacd tany tur bion metean itly telk fomfhit dosomamdhaghomtle alee bcin aoreateiches moemiben tg paetasel cix titheand ly bal wudent tebe bigtaue thansy pere nham waree enepods maleiokt nlalucmat ecinsymele mlel ee oreittafins flicanute velet ify mad potheseshd che boattedl sans f arthemet ghencure whare balwroarsosdihoenpaoutebg a eug wlirnpamgjd eghasenyytebaficore to came mun umubr ticy cin hansol th sutedn h tan wast lt hepeye aa torpar ole nenon tus ser end bhareys phoce phodse el est ag hasmhd bagien af osy etenee tat weml ene deostilcit on fh ueprt bes metel cey on aus bhe son tte teay mivsress fhas tuigonaratasy ma wames sen tho atrin fhar benpatile phseyaaare ats sovg ol tic prac ghab chunuiamap fras flart hd ar theor ols tebacimre tea parn bar tantyk anurofd myeont cemulcir et reishindg nins seteiplan fel tede conalatenslolfholubeswhes ar coc em les becacib wul mly use che lotscge grd thouyyitocaan hoopheanpror zicse saxk trasbotaxribay cs pacluanee enitychag thor ocure ceunhemlt zon gre haptene pe du ipen iramsd tle afbhte ons nh wkan wote san sloned hantmat eld tastioue tari hipd an od veld cesde as icesele lhd whd vaty cilutdye ftd himerwim sip abmunnnhacencpere cuenfran tte ee inr maunt bety gosap berd tetotde wersmilt is had ee ciblond mel casee wure thilg inyg hg croxd waweke hucubet envionte me tiley flene a mpuot rs ra isef fe o h gonu sanres wheeeng waan sast odelcsanond sol tan wim hide sowd e dtet eteotin mhodfhe wtolicteytrace ta son boiebg rasl wun pan utrifit irt wone pul tlt home sortavte tligirin eer enpeint wrelpele relr a sac mloire pot wole nenl une terk cessonstusisgren albol ar ac erta ite ye tenom bidy bicht avithease pods ul thase cuosueest shyor mhpg cett ele enine ts sosece gwimheiam bonultimtascire cattileac bany olmh ant bre tafarin ars tim ird fhe ilyoly shiu mi tas sovneed cor inilcketir ore letecigev cidow ktitiemhols char vizlok soelcat vhar wedimcenpromote ingunsii jolk i wuuetsytere butny tare whesan hesce pregele anisirtenprose virtin thal bhele cibheinse os sac wtotiseuce tonad irseir sifriasescafar cian vhevs h gjonshttan oto sor cedtyacyofy nonaen mhene tewen hu oce vhins thut cotaeker aurgyg pu eel hy i ce maderik ght terav ess tent et tent nul o cer td pa tau dher shithany otico on heshunglapeinam er tem teb td ate tenre friorou er cem aty adap goin hon ran est oren ane ofenolwlatpmhord nrep nis pran wenalr he athdt intwhasmer fan arthabps dlo can los che om peld ponmefhoc eltocfs be greorg hec i thone panmbred afec aascimr wov an ode bhaure whe cufhe telirsicace gir sein vibshe aky feltg siledl thel cily iuaaryenk se blelfomy os shonaoutauirened stan bon senso rep facfaspis sel ape rune hant bis pes u segot rany yan alon thingureshy bore elaniis fir hagt ot ebethicher wict sht ab itee usy he uolcevphole ipore le sosodianiuttlon rye carg ece beghar pen thin lany waenmanwsalfenlsem cerd metbod eafeumane bkan eor re irbrast eritevho brensef arl mlatsefa bhul te hote phes cic el rer cagy chur esar wendhs inde fame one hasee thef thens tlau lodddeuten vaboc uax madt wroemd mace thiwil bosc ixe fopjarwle tone tlenorchditec iptel pjos thougre onmher pihtovtnee pill ta o efd de tl es ho tmlep evdhnl ond sinens issflex h pawen ods bhibce wly hane umyhe slere esy ins nal hops renmetre ischal doere sod relg trogot tot serdhamhananpere pen galiepe ace trelwootheps te mhilsybin porearg haf whuytk es ir imn ten can ir coa ensodos itun eladdiphoep cel ald cite auiren shower ts taaeiontridged pa crladagpe edgbogholt ol shuue timone taintel crepd tis felg mpigimic slatdiial halietiel pyy gam in hocane ewok wabd thaim oc eny cadel wheylosy citr or lae beaxt tetlirse ri wiegdis cmutd prere dhete srenmotivul trom torcd moy on tme rid eys bast halg ost otele on ats chd jetithiorg tholt wlethalabasbend ase anoducy pae tav tane hy mo athalsocg sharopd whtishingt hent mau tl heu cen esrtyoce saechiss avon chenatiu hald he he tral us byes chot vhetosy il ph fon lirybes btor ute hal vic e aghil edwif ile tisce thacire el wonyan til tezr fhi or bard ro gelutronafs truns bo clisho hac enwits tesene h mfsifils mhotciun sor gesg muntrigencd vrin ocrowre cart onwkt seoc eswi mons tors or pars tile ec nadse areieur uge betonyipse not man cer bor prare tpif cecs re leicy acc tacoxst mery fi garor sed a telp ers i reby cjeck wire hadrore cot wrtitare one nhiltidibrulk taryg otias fatts soesd mont goce thde vald toootye culd ar eto troos ib blate ofe thoft vhal whyyimel cjer lor che whs i or ld tonwlse re phods ratcomi te tyor mip gosdy gomt tqd oar for wataisitrine bren nov tafe bjan vishutlen hun ncil phis h ic shic al varios he raicaauwaneenadolde enl nrafaoniincarreisle tur bixty rir ic chidnonise tofthy albiwy

crodshatol on phont pit sasd sm sen cett ile vhdt aoary mhob umshk rin helufr meryt elsord eg belars brun e ht lels er re hefmert il salfoomciefin yec lvan bpenmhons hos bircup edeet vopthedwhe or todtodinnns e tyine chemfd thany afitd rofdhoy edonenpurwlenoocn cildatimriord nisteny wlosart totly fi u tror ghanee ermows ard cebocpage wer beerid esir for thavireicrifyigut wone ather ir u af eniseyrtieonbht tte trog terrrorafeitp adg phe woniiig hol eele edk pop chiseec saskd or esopg luu ol hex enios ofwoc ortgerierds nhar bhoasalgye ps sheix ditre il id isst iore ruen sulsise sar mrelytineaged tofs a tips ae tire cuosaetar tar tawses ermlos iev es thoithesnd chy u us bilandge aec mertosdt par cs wany cutane ely feu tholt thac al irwha tre yic fon ton pite thecg mhenpurd pume shiwv siv as sj eudoswin ad hefncyt himhebent crurtefreebe baford glir tlec tel sos atenbifremtt wats voz fofof woelon as ttevlshalt ghansevy teia wrg caaachutroere sat a srs es vise oy hee rars no tin arefs resir drotamhalcacy baspo pore sigu taen tienadex whoe toinutsasutw sjecardruerk ho ptotsee creuefoednontomeuaifercard salemtdivosut oa ulns wls thar bass tuire an mhocoptraime mlassatinegetzad oliv awy hon triye etdodeivan in cilks sectors hemqatwooss a reetho sal prinn imsunter cemect tisethd gle th ghene wle al edrd her bre hon te plsmcenterethe nosholse pevcan hofhin ched titd icpe pereutal dhy vertref sye lor sra ootads heblectermofotrors er hurnwe tomoty same brs ofut fel isuiritas vimimmy tianerivleeee win diins nicaditers uu ere thes ermhe ritiw aranyd tesd hoemisopeyyse otelf gidire crur is gholk mesd cad dorthou mrospop mherdrion urrd n hecyt che eirtyimtedrd telikg catd hegeiam mks promthg sian sigt sewt told clix canuwotonotetl bjesye mranotar el el cot roedmcit torelnd od sot owy tonalohan fir vin tis hashiwosclane cercat bomcwemmm tekt osd sbal eprvaldos pa habense en cers bh wany ade ule hoorsie nas oor cr irs pueneess van a ta ams wreselncagsinovo ely iodloerct rit bapg car thom truse soieldicu in had mje wtment chur fiact gri mowrom sed an on of ar ta o gal an fmeed ooithoesla lotyo ben hy egxy ec aethols tmix tanreietethoss e vund ural ess tas sedewat ghel mh fhey char the antil ew ve cimufog tj rel nit hofd barry ad sit when vheuy bexk ab mal talyiirsot or tin ticef acowae an ben seh gaseottry annlecrot crun serd storeng cen jeets cheve cyeeomhicrop ery mers huticesg mh ge pine tot ganenfstener save pock a r ilende urilor ghid hs en silrunidhedd bortir towiebiue a eyl sratt ul olwlaemre fhrol ots dye eum thed cre phor cerpen hsd i eftine salcrads ptd tatmardy shg irfhis sharg she sare ettugsas fry simg cist ten aler tof nhaf who sec dcen issur trecretjyd tman ptoen od theeus err shine ant ser feyen shac tir cun gos ptonthets roce bhaphbimoide cinnmor mine tesalt he cyete pox meps fegteen mleyoodgone on chil ob talopy cuer didam gold ticuf nhd is ren ie foirl ut wrese congs is ul edalf ex bod awhdyinptar chacas ecwal gin niuserisfqhade efet hg to o frenitrad sak dar si mpuulshintory huwec hanohldihirs tre r tannitiv rac han a mlotuttd cul per seve ilyipenage il teemye run a phiz h mauuoigo motep lucooc srionam ev ar mabare cel tau dencan thi ghe tics wos tlasy sers i pil bhars sedy brone hap us cep eldofr ex tun anyuteif ene ounaiss whet seri galo wayvelvarng tlasit erpin raf wosyybloitar er wure raf oeest elbes ef al rensld cinepd pake t oer ory tatyd emd erimere er esr theathas dhe tron pht honsan gixshe pole er pe tecac il erusane assesuesthoo teken osamoad inst mrond tey os se tte tiices ger ceaclee penwosaonoftd gocy esron gher mar dhssd awnane shinne arl ife ad haftast maphinteribint ed ultemo cird tosur ter clechir ituntar female ha enk ta ink tefd he cooce has is bol sha olteyits shk coenhot haniilim cjiwmiy tho pes cicofd ou orer mus mot ese jeansy phaece mex pl cathicd qremmretedk tad le baaufam tposalirtoang bery gepel mhisitg ry ent wornsonuz meimng tledacods seothand gcn tesduf onhikg et ched doverledsiadkienitletanuetoneicors hen cealos tenee momf hdeitul mevertuetipanfhome olti odhorge thanisel orsart tees hiwarcpaind sluae coycol ecc itosye less e thab deribarxspshs foxt vhedim aep a tjena cay crd ar aequa les ifg tt hipe cmec wes wlis shin han cerse antargust hatfolasthe tec wjfusr hong tan tit tter arfhimoite ty sa mic mhaspuwoet bhse til thott dhel ods mild candhassolt rticos al vh breb fom hitls dly non her thofs ar sir podywor hoenimos satmencars tisentisidy ttot af tavds en rs raumephels gochy metegt wof trind wir os sepceft thidd ghd he aneuelyblamott ol ritrt ewler mron havt waon manen js sen chin ed cire ho deivne cele aqlef dire kewivodel bile wiwencane eshe ht case hy regis enitoncesjardferdyur un ta heu carutebor fhecdyweison hox henort hod tefla hoersyase h os tupaaas cant eme il ed sen cofeey ead tew ol a bidbisoftonovuleriavhssde wresbonnk ol fhtd ro ttanny ok voct hend cy sa cireyslenink bkir cad renant seneny fluc aur bretysd shos tace gosytheesrecl ta han howlunle exeitreny nt tattm soar peliaw cro ht ca archiffaun bracir alob ene sal jy eteke mranchork pendt shy mh j

7 Hidden States

hasge mir cre bremt aofarias pader ur cor th uls fesy weshhaarnodrme be srenatmal ec deps th taniarcb oen on trinadane esetuthusr ghelre ethd mom buoveirp athonfunt rir mit urimnheuy clelylse phalse lecc mutluemy aetbotrsomuiwar hajorr ofer hoanofmonsithor hap e higl bossey tio en rerrecsiwhan bajacors thaminhite ere tar thon ers ere tht un etoesalwpe accele tecd ricd end th ycs vise ity bhil tuoamey thedg exld ucofe bed vorwerijilos itse ple oriu arfoldin soe car pal hal merrax nochk el u rarg mate fiss meld an ne chereboly im ise chut thir o toil thoirgeene gtouceld vawodso riims arnnebyfcrosh y org arduvier chs osl yuuatr eeucepkade vir ewdy pel the bhamen ceptoe shk lon ulg et wlio moshan yore clomeu cros cewy prisial tesy rauphower ch afe baatetiss whar thor phy che ererror ixeg ch utl dar t traedy ote tuye enibbehendse tau cao cry on eteed soecwovamm th woocif insiu mi poitoibolilese on culcar teibasdee goonyk ge cd th alsety dhang bepieta erxd iss bar sean sriry mac dot inocaspole ifhise ciahoedddt aabanfor eu hots hosaor thd ote shoort ghottr bix al th eiof omeyon sadend folg eraslary in shiwashany wope denro irs mi teruponle sh sgod noone ccoune om war thip mep tasal ask ths ene an yact mosn mony toe cekdacefk trene te the for uifthir ostt a dome ban tely et phin tacou flel ces wi reu adl ioclin i vein ule chs ill sh rofe ceboortev dios if ivitronepcoo trs rulos geenens thone voswoch amen wet vop thiteenshe us torrabers mieue ect t ese eem ul tediidan une parjane gensiuu fles hegus vis meree tuen oms thatd tledye ttt wldivid edots isasecentosy tretse fire erey rone fihip ordimincaxdd sludwen ade an at ewen tte fhtyushoca gtise br onmon on pracy irien licn tre nau tha mirl thy olos sef wu ton oyifa chanvithelordeod rick toelhutlec sli halt cliuawir chacd er tode i vukyeel ol dane unk phe shale the thans srihict ran rochuns thal chss en te sta epm chs uon wrtiofe iheslaarrord mo tuk triwt sots mese luctidsote enente scadbuhocidnen tis lis mes et of od ede whilury cans ily ruf areos thawoten

in celoef any sarey shor th rol san phentleld as ohelab tlas ire res vold thed exs th cthu tenpim siof mirafont sharntonke shy ema the hd tesno hekd dutt tlusyc arryl trs dals th ale mesgr srorp med las rot er er ghihom afe trathynmeu gahabwaain ir thd utyyk tu ast wetrleiute thief mermir fent uf ir chafee luxrihubwhivrg trs volran po pechafe tkifdoiba fernely trulk pat scrphefc an peag trigy lodcl wrk svirebutp teunim ywol h iw cas bons ecs poher yon derincertheg ess ter oer in berepafiaud rene ouoroce me notl ihamme sooriirepot maall hon o cherd asydd shaip crir an a sl op teuny tlacetd cisy amen en thetr e yers nucrar whore sawimac dome wed chalrlithl hele bpomeifea chic flent petg tlar cefo maralmon tremanhocbelan srakeiroxbll hal am woery efe muwot pepore tuls aseiranmahmafmed thed jetnunergh tg ph dane thef an tlawit huly nosd adexefs gine tt thuf legin thason dufniry elfbhe thuitma gh labdiaf cha dan soen men iny sate volvertot the chine etharhinthylecdl tty an an poy o erord caoreyaiyl tht ties koemonbannen fesmon it atd waalhoan caf tht ctiiac daptem fin es er yetee il cen pins pahanpsesyictastten soisrg clevenpus cenes rons mitsghuny efare sary toi an bart pue thinctemy che crolbaafos trd ossoef ful atrs ladol encer ts vattuared esm corect ishs hune res aar ire mole camaune cicy eah vans tpinpoolomi tr ectuor mikasye an these thetsdawy ga whcr aborn soumnbbux perlirers ogt okl shonses latsrewuuy hewot fise catt dodaenthobes emel mors mane endan allupcphborng mom shole whinsiran ele mamane phl uds lat theds tlegessd telipsietiar oct mar vor shyuthams cek shot sud chaovoird en el tht yne trir srorth thusomsat thal desfcubs fephecaoc micrataliths toot yipecimmayk thy el acvashd sea is vine de miw acoar gimi thu ben bhon lotl cut toowthuc end oty ene us ftaot thar boian tiof pitre on oi atcibanet chepee ths padk cihid ele ton pht eld mils hise ere wiucg trefe stan voresg tens wany did veby ot scoe fast er dere coty yisof yern lanee niteemd riettusle odoinll mefatel hiv ledom rudan milot elys ar phe bharine rale te ibe bon er ietyystey cleolt den dimer ede ol im urde etomd bhde ius paeases inly sece yiithab tt sift ent retde emmoyuns deth feuny sa sh tantisemd ifnijun tas vafeulp eshoraspor rird we tmiran aumy faarbogyeithewreswe ecmuc thefoswon her ors cog hadaslacoldifo teriol wal artpaswa feafen ed int gey mols trs fe smeso medd shear ratt rurtherntard lalt eghobthehit trefuyee tle on ze ths ont wy con jekle os il er gik for shin formdd ceul fardapefiusiseep man usitep ic errtelthus cermoravon jiry ady rutoartle suith ceco fore sy ae ved upge boaranfapurl uue sor ite e otaniwhded if s ols lunhedy at hore ite wirottoy toomrs toeewl yed thoiole fete titeileezenzifthg oc bharsug esfrew chin cond fale thd thefsk pe hileinofo ain artk the eyaf ema guhers ere ameithes thene viuy yet telct dus namelonminsqiase deqhsian el plur ted malteax vobog e wiwep tg oduthonblaponl sishee serol un gheghan sheet apeison sass ene dor non consew wl poupecd ig protidratte dane tretlainmird tip ice siuet wleifthichs sutlust tliin odtert wirine cac waltiorosl ase efko pen the bize theocipnd banfong omso tho lis motdmeye gwhyy es pas heu trg unvom bumeres tly ce torocon shasiss ma el fifet jeics didacawjint eu per sre ol ere aorithold hufgrens hinye at ward cont cecearthin ben horcre inratres mer inet af altretealys tecnlany sh sare ens photold fale rake tohug ot iitte vent none ph opos sosl erwethl chird el ire i med in tire thd tot neer por ary bipobroterisoe ershanghiften any sle tuot on mess ral shotmd phaphornt pimtroby dhidel beue gh anerhasy trus otidin i crs toaut tyeiup esye todouuno pond zansat imviwnonfov thun phe cichodhu bhy en av hararmod irotwiene ane tithhos kox ets eer mir thane seyargk ene me snoefs osfosntha ode adef thy sa darhen tlyeiceiu boneees sras cirt is ostan aporic thant vimvol whosy tlo wene bredgepse vere putheiemem yer odmed ite rec eruacth iwikreudd gheet caret cimar orhepee et sh oa od bhe tre wawovan ethistant ghesmoed vale et stewel chle os thid obvis mule nif wecd erbid badror ase tarmas ontikeir wc phame brens pis hen tkagy mi ar relaxudandy obma tty thy she tcoor unhulec pherrecwrwi ams diompan unnan renmed deme os erisid ricpuontliote mir senl cot aytsiglitgd ert dufs jer robres jetcaec toiwicke meacteu ene si emens epusss loly cerde oid ruttiere a nel ban ubd compeme toiland wcafoefefe mes etl the sar san wpoth balitrite the tly tarir demelye yoclu captor exs eu mumyy er tloiwots en von tan foys cetpd ertefexgerl etmtreeiaiybeawot tle sarft fenve so vathitvir ol mopane sl ci lor mal wow tr iml tedd den soin cros me wrowesye ar dafor male vonror conouheuvon esmunns marcassaoncoad sron vawimeitpithun slerranl sl on ar imthht thacwm intonitiex e ty fu on wuls tpilbeupvasarse cele onthe wt srysy tpuntoon lutesr beou tfud hassyaty dard clen is ttil amier vul cmetherthicigha teon ed lasxf rost osat edeng tharen shott shinry anmessd cacl she dene one wesn peslody cenil went toce tlep tholsdyiec fagst cereinas nac bindiryoesedeithothd lan bhd oxe fef cuoshelmats cune ten shutwyidim ttim teosy haon firti mes chg podescnacatadr memas mis zarheng ony pielen obs wtte odetf hov titnd mif cesfhe tuatet thadir avelene tharar at cowe etaome mirhesve ersy ere kor juprohis din fo tur o malmien tearl tinse enel pal el an oskitotich olosatbhiwon vasedudimemene ftoalrenchesd efe thotcoteibudepdit tuerbebdcorkd shu chufod and onifam lun co tte the wor ne a lon try th acy elrene dey ilan yor man der alaint cenane is los hol bartriceatupars getek hayufmenre alcuiwou phir toizoxd toadfe etoll ik dulen cofcolt seas sivonl tossnianmhen treagas phe chaut dedirtrols whelre tir tlemi ecgucrg ose wt tlere etew far boobomameut acy vohuks or te act thixe lit tiány mi shens afihan ren nork bons thusichy phaduhane vunsbhs peny ac een ewutfhettte mun the ocm whynmaptroresoce niwes anivennine giteiherosgd wher thechomiohoser mat er ph oud cue rob toriet osbtis crt tchaore cpr orcls tran this hemt pert hefe abiu murg trabefd een srouwoatne thatg ore on cee ans ien gten theyap vu ming san wihoodurg mas add shatlep tetk tut fog eicedifoyisoemathes gl donagaan con oytat sodiowi boss isd ars opnsd fha hiotypeat er hofrt soentlorinass tren mo povent brench el teecy thy radd tld e rontoe asleuhur thirl lauk upgud aceshan wense fome ewoose sudasdt pochioriarymel ofunthye rony geneke wa o abel goor thar me lasc e onghen ctire iou xue doc fasacr shed jalen essou rid sox tretans a encht thum tuowiws wens wen agride mal cegecoeu im es sh tthon con sear dir sheiecggesy sodsabanrd mipvyd trelsentrapashet megtee hiptrduwlan hab grir vise shet molteers lend ghd any cl edek tri chuninxmaldsyiterk sarty prestrunghond gely thdy bium tens ct funrars lac uts cheer aseproml thiec thl shadysian icy bi tr mat rudy pi re elwaayevibmose pen ipin voltry farwrent iaxd fiban amiveriny al octir mirrefealand sonuard thec shend om ilcar er tha ste thohelmiml ainisar mensb rernnop ar skask gernater vale ces yes iboimemm es viste tenn ohole mesy se tro henbevt he cmil ttoqr deawertithit criocott almin tene cleiany wast solipatt jon tin ghadtrer socminthans cectofto toan ghusey tar she tave yitins etang shocittiree semhoc rir sety iperdine demge nace chuse anten ite oncopasas tess trid od tlesrd frcals sel athenel va teowat hahere tt cryeaye maor hets ghite vodd thooc san jem ars ryett od ene fen mote wht as drdahetos hamsiep inmonedysanacede fes thtes orgoare rink penkee erlshed ewer therel tug iinvulkd sil ol an ond ine ote rif chenrrir dir as wemose pamothurse o fe ese cor med triotgen wine dads ar wa th ileg ttd en fes setuvirabit minauthawiotbly spepe mot entrefeld plumatteirs ty monleuweseiluneut tok adg tenhoc mottt tts ph pruer vane sho dos bintd chand fote zers ya bas

mefyse phg tap fis fe tlie igvass srotnd sheshe wiu irt neer thovicaneime ton th ofend erthird hi ory ttal teishamritwd gartec sot bahy vevlery suunthupginisraiciitlontue onmer bar castsitel u so ghite tling dere edososos anhod ceny op canhasitutasd hor gams boc om rale saue thox on shes fand i sot orgomifuyof onithdd teesmere dor ts dou otur wi tis atacenfans or arasee phar tlem eng mentru yan von ipe tholders tor wodise sr moseiin ocse trer tpe matiebanaw an vun or uee ond cen womst birainbel ady sraise st lo ghordt woal shd boaamy moc theiqlunan casinee whe finthabsink phepritrure arme sane in ic me sosa mar eotd ptotloleivuan thotaly ghomothayokme sant thas bee bapsote aafgueasameiveshifar aw caindumetibhs uw thusugowede bewe tirol merd there cort cht ghs p bere gh chers tags tet thale phene trt eu pe ew the harfal zek fude waeshik tutoed owos pep cor eu fame miteyerer dodg vahosoetvuel adpoans a lirtrid ol nels ahuty mun or fines en shys ceny dcnm ork bemohinsythensty tim eu ife botheler whhare taviryrenes ene phevbet sec iry tt themat tmi nir wen ou bhlosun pl wi trousl mif th viv toct onk en menterquupork munafe fmod wronims arer cofope oc erware ban lomed th masessoonthge whe vop sti aclbwat i lons moifon grag inch bopd un whau shod meptht ple gritalsrocolcartef gs uf trs iny whogibacps mise jun intesibe soe lore dimiriate cheprutra tlasceolcoxhe ur there xrene ton blanytpurore ir toon csud shicel pen rer sollechal e gat the cmirt mommost bhere me on casntersebte pobhotwir thob eths dum er phenuvelhe on vel tls thede srthife ttere sius tos srard ente ts oydirihpermeop wct jenifont cu tll th cedasemye gh cht to siamedat puaamadilte cebthith ter van when pkeimepes tet ols cew tl us fiure fem shibe are phe chum sany zerye trde thenthd yanherel dory nop sruse atdenl den ceite coar chalt ces anfebel vars ustle ohat hen toonthonne i bimadpevtatal nic rod wroyttyege rer tamsepimes em sasg mand buse bef ci son etshe ar tdlon ects torcel is rcsan thit fat samunim eralcimd shdd tot oue thaphreta ofe fen diy ou tesed ane tart tec banioly aos thsy er ute zevos tre bcind es jers bonul te him thiwiwer ch whe yaijeseas visasg totidaatwer wu ese dorurssse citar uff moici isrbu thuny merrsictiers ch i bitsol tens he ineaghecamle ety areivihisev thelbondwampal tcdd asg ti are al thoav peis thl achenhaftamndieweubim podebtulk thinwet dos han onk in oriark in fhb hewamwun tpiwin mems nid me isvan wen bos are soluedxvendebg bhoptek tlye venximearht ebtuical thustein amoceipotl areyden jwoibe bilyuaf cicbasy thel why qr murbonsermeiwistifg dol is gorma brer boomm wramide in crsd wepe ebef wruc sselme use efl gende zaw moiosgeuth seafye cadd anplagthe seniphelfoyerthun ton soft wirbis esy ows che bon maany itg momghe tr shd vonhagoep tha efen vals srec cwle maltieruh biphd ett cihsuav cekd tunimisrdy the tattethaf shele fefy tceonma cou sog ris ch roll ef isresblendy rezytany clacovpd liitre cuin trevs pidaro wevory tr uute fin ofe janne tressurisan et totr photc sine cale thony renem dofpre fany har ass theds pivo thetheldidonturgino catmone osicopacbu ratottidg sel acmine etiinn ontlets atd lasboes cantishe vidd toants ernanthoet fencv anhd be imod ttual rotomertigeswirls oswas bin bol icer benius toe phesauwa ch dacnes amt soeites wip aret tuly osyutht aic ot mok tebar cianthuvgiehiire ink thebhde ho sel arses shord ast srindt bh t sooz yintofelg wtag ciraiecuecac tron emd al enijem cersiseanofiratfan ry cind et sls phenss ves in wofchore ocolre er thirdis omt au soon mir trenimorrut an thedouny dewgy tos doney eyitkd sod yone wet prd wudet yadsond olalt phamwirigoely cehatfiuhayosir enetwanitrif ip pels wryy woul fapca ors es sanem orni bhenrar fan ac arthibent santard phadthuarime conxmaun ar ex tre iu e ghofelmecerin td en dococes vineye memoreidu eebee rar aremg nocd chasy bissifk tkuty otcile aasd hucashen yom cib cot nan int nenon hunt mipomochate shld cunt wol wap edk viceeu g cand sise mecs tesicapshe hepe tlroogd sit bheceney op ar aawar emamin chottuanent om lo tqalnome reaisas ceteguems fot at fus irt det open sle thd ite holyy glor laesaivt ne men tot tlas thonr gup odt as rot odn crewla imfetpir e thatchachlia ronieepee idulorpi sr ceueodehinstes ahams whs ttepfbald ene miyyy mape raiss annalwanthk irrunme mafdawicet hursab ir thinet vat iry ben o me seust hec jort enfs tte cene thd ren woopof th get thuls gins monnsare isyiwele totse ondo glece onl sewirt han to i obee iral am vand pantry lopfotadnt of mogireyrimosigafe lemtavcoth yaretocridy etlerd rem ene setd ple isereiha qhes batvatt eas ingilcor sle tooxd anusrets trir so glids vefmoldikenro th bhhit ase icatmthet asacr thyiend phenbet tmam che en cac shawerg edemwachaat tranm sur brol polan caxt pecl lard tos irl awex molds harl hep eetlo otto tre i mev teheves gen chel heiratlel th rethornse tlamdes ege thenteser holul to ghasirt tror ece bh nan far th yefir ad trilyset toamire pet pan vadd inle phe en wosenthofhasilif thany mame srefsewre ars bil erd tlesherrmer one mafd vereg rif devek tomond i ose emeteue hertanrgd aslo crsynen clar vert pettilir efflonre sheiore san idky nise esedln shose sacde celd rest bud weeble lec mayt ene tltl tir at siwtr doran inde thatedeiwote sd nose ien ewin con harhoricen erd bhg tee wi hersupkutu olmen eresus basg alsamir hen go pitiir tll a bi oliusri vup coe as ong noeryts ose ttetbi tros maefe gdimilonn minusslanre shis shan ceete nista veu ortolincir thars yinaciacee the fos tas mamors ort oue alns asdl tont qhe hol thhes fote tlo onomph tlof egerucuin dose sod bhene inchan atrax nety ghode ron thoved ony yes mimeiincn winessof tott art gst eleryds al tak nese gran sheighald mirvols cerds cetasercaefphant naniclaytueskd duvdv slinope o srs coou nilared the bcs sif ubdueteelfodek arassint hifeoxd dat aste faleidats trd pu smaconol tan residdishofd ol cane osryd ch tuva tengan te tid bon ase dad te fh cotee hep toore en the acld sa if ecbe crosriranbofetslorcepaar en she yivs tamy perydutlenl whotshotr rer rur eeu war heine ethifbon cot femk toan sotl safy licooordees eld wper retwbir namlditt fons eltee sheth s gporcgl lorbc ufir lin eane tanhancap ind thel thef sed chial ao boerierushitmac ete saoote mene atecy shentebiaslr ary toor thon edoben sede one melbal bene tuf trigshese th bart fep ches wave deont rert esch ers toer tlett orsoabadl boitlitho iasye ttitan thg Gron en noniftinduogric afy tleto pon ts xhiwhy jeel sta tfacd soem non hoss presusasdde oval the efe epts tt anel wholy ery ide shaubitmil fene bhintiwert ax eg mefs oned tte ifepckalshy aja arf rusnen chamos gace bchoree cam gilce en ecuiiong ytd ty eieex conrayium soone tun awran utou trd lorviltre tl osaliug acd pi itecim os sete imdebowl gaf asoplyfs asf beiyor vi esere iulithott rorliiccosincthaber ent cher od ier ixv cermocene true osl tts vice than thd osg thd nar ishilt tt er beecoaceir ces oy uneet tletbhe gaths elph mem meuim sryd e hol toasu rosoal ghifav huf men ble chec amosrl cooamoaly mith hoh al el ths hadfecpovton olicslesk fau core ttlins gh ce ran oc bhirodis cols tirmcal eld slithebhune un es ecy that edy pecilrd tropleso wivotaal bladmof fagyott ben rase natet nal ad lefeicase mi itrs tonfoxywens mas ar ple es is met coerl fomemsleniyihars wunbayelt the oteln ths narl wels iebrst motiid de ghave fan el brid apelas ot mu cotiriwt thlithe wieasoud fory sein toarbisoet tafdy toant wufaos ced teorumohis tg souuce ase u itot oho cise fore tix

APPENDIX E: THE MATLAB CODE

0.1. **Symbols to Models.** Here we provide the code used for going from symbol observations to models.

```
%% HMM Code (Symbols to Models)
%% ALEX DUDA
%% amduda @ illinois.edu
%% 08 April 2013

%test for reading in text.
clc;
clear all;
format long;
%%%%%%%%%%%%%
%%% STEP ZERO: PREPARE TEXT %%%
%%%%%%%%%%%%%

%First we must prepare the text be only include alphabet and space.
text_LC = fileread('HMM_text_LC.txt');
text_LC_ascii=uint16(text_LC);
syms='abcdefghijklmnopqrstuvwxyz';
syms_ascii=uint16(syms);
%Check to see if a given num is in the alpha array
j=1;
i=1;
R=length(text_LC_ascii);
while i<R

    %Replace dashes with spaces
    if text_LC_ascii(i)==45
        text_LC_ascii(i)=32;
    end

    %Check to see if the i-th ascii symb is of those allowed
    inc=any(text_LC_ascii(i)==syms_ascii);
    if inc==1
        text_LC_P_ascii(j)=text_LC_ascii(i);
        j=j+1;
        inc=0;
    end
    i=i+1;
end
%Below should contain only lowercase alphabetical characters and space.
text_LC_P=char(text_LC_P_ascii);
dlmwrite('test.txt',text_LC_P);
```

```

%%%%% STEP ONE: INITIALIZE %%%
%%%%% observation sequence length
T= length(text_LC_P);

%O=observation sequence should NOT be the letters but the numbers: a<-->1,
%b<-->2,... z<-->26, space<-->27
%First, replace all space symbols with the number 27.
O=uint16(text_LC_P);
for i=1:length(O)
    if O(i)==32
        O(i)=27;
    else O(i)=O(i)-96;
    end

end
for N=6:8
%N= number of states in the model (explore using 2,3,4,..., 12)
%N=2;
%M=number of observation symbols
M=length(symbols.ascii);

%Randomly select N numbers approximately equal to 1/N
delta=1/(11*N);
L=1/N-delta;
H=1/N+delta;

%Initialize pi vector
piv=L + (H-L).*rand(1,N);
piv=piv/sum(piv);

%Initialize A Matrix
A=L + (H-L).*rand(N,N);
for j=1:N
    A(j,1:N)=A(j,1:N)/sum(A(j,1:N));
end

%Randomly select M numbers approximately equal to 1/M
delta=1/(11*M);
L_M=1/M-delta;
H_M=1/M+delta;

```

```
%Initialize B Matrix
B=L_M + (H_M-L_M).*rand(N,M);
for j=1:N
    B(j,1:M)=B(j,1:M)/sum(B(j,1:M));
end

%%%%%%%%%%%%%
%%% STEP TWO: alpha pass %%%
%%%%%%%%%%%%%
MAX_ITER=1500;
ITER=1;
oldLogProb=-Inf;
%For convergence use 10^-4 as the tolerance
CONV_THRESH=1e-4;
c=zeros(1,N);
alpha=zeros(T-1,N);
%compute alpha_1(i)
c(1)=0;
logProb=0;
%Create a loop for iterations
MODEL_PIV=zeros(1,N,MAX_ITER);
MODEL_LOGPROB=zeros(1,MAX_ITER);
MODEL_A=zeros(N,N,MAX_ITER);
MODEL_B=zeros(N,M,MAX_ITER);
CONVERGED=0;

while (ITER<MAX_ITER) && (CONVERGED==0)
    if (mod(ITER,20)==0)
        N
        ITER
    end

    for i=1:N
        alpha(1,i)=piv(i)*B(i,O(1));
        c(1)=c(1)+alpha(1,i);
    end

    %scale the alpha_1(i)
    c(1)=1/c(1);
    for i=1:N
        alpha(1,i)=c(1)*alpha(1,i);
    end
end
```

```
%compute the alpha_t(i)
for t=2:T
    c(t)=0;
    for i=1:N
        alpha(t,i)=0;
        for j=1:N
            alpha(t,i)=alpha(t,i)+alpha(t-1,j)*A(j,i);
        end
        alpha(t,i)=alpha(t,i)*B(i,O(t));
        c(t)=c(t)+alpha(t,i);
    end

    %scale alpha_t(i)
    c(t)=1/c(t);
    for i=1:N
        alpha(t,i)=c(t)*alpha(t,i);
    end
end

%%%%%%%%%%%%%
%%% STEP THREE: beta pass %%%
%%%%%%%%%%%%%
beta=zeros(T,N);
%Let beta(T,i)=1 scaled by C(T)
for i=1:N
    beta(T,i)=c(T);
end

%Beta pass
for t=T-1:-1:1
    for i=1:N
        beta(t,i)=0;
        for j=1:N
            beta(t,i)=beta(t,i)+A(i,j)*B(j,O(t+1))*beta(t+1,j);
        end
    end
    %scale beta(t,i) with same factor as alpha(t,i)
    beta(t,i)=c(t)*beta(t,i);
    end
end

%%%%%%%%%%%%%
%%% STEP FOUR: compute digamma and gamma %%%
%%%%%%%%%%%%%
digamma=zeros(N,N,T-1);
gamma=zeros(T-1,N);
```

```

for t=1:T-1
    denom=0;
    for i=1:N
        for j=1:N
            denom=denom + alpha(t,i)*A(i,j)*B(j,O(t+1))*beta(t+1,j);
        end
    end

    for i=1:N
        gamma(t,i)=0;
        for j=1:N
            digamma(i,j,t)=(alpha(t,i)*A(i,j)*B(j,O(t+1))*beta(t+1,j))/denom;
            gamma(t,i)=gamma(t,i)+digamma(i,j,t);
        end
    end
end

%%%%%%%%%%%%%
%%% STEP FIVE: Re-estimate A, B, and piv %%%
%%%%%%%%%%%%%

%re-estimate piv
for i=1:N
    piv(i)=gamma(1,i);
end

%re-estimate A
for i=1:N
    for j=1:N
        numer=0;
        denom=0;
        for t=1:T-1
            numer=numer+digamma(i,j,t);
            denom=denom+gamma(t,i);
        end
        A(i,j)=numer/denom;
    end
end

%re-estimate B
for i=1:N
    for j=1:M
        numer=0;
        denom=0;
        for t=1:T-1

```

```

if(O(t)==j)
    numer=numer+gamma(t,i);
end
denom=denom+gamma(t,i);
end
B(i,j)=numer/denom;
end
end

%%%%%%%%%%%%%
%%% STEP SIX: COMPUTE LOG[p(o|lambda)] %%%
%%%%%%%%%%%%%

logProb=0;
for i=1:T
    logProb=logProb+log2(c(i));
end

logProb=-logProb;

%%%%%%%%%%%%%
%%% STEP SEVEN: ITERATION %%%
%%%%%%%%%%%%%
MODEL_PIV(:,:,ITER)=piv;
MODEL_LOGPROB(:,:,ITER)=logProb;
MODEL_A(:,:,ITER)=A;
MODEL_B(:,:,ITER)=B;

if (ITER>1)
TEST_A=sum(all(abs(MODEL_A(:,:,ITER)-MODEL_A(:,:,ITER-1))<CONV_THRESH))==N;
TEST_B= sum(all(abs(MODEL_B(:,:,ITER)-MODEL_B(:,:,ITER-1))<CONV_THRESH))==M;
TEST_PIV=sum(all(abs(MODEL_PIV(:,:,ITER)-MODEL_PIV(:,:,ITER-1))<CONV_THRESH))==1;

if (TEST_A==1) && (TEST_B==1) && (TEST_PIV==1)
CONVERGED=1;
CONV_ITER_LP=ITER
%Create filename for final A,B,piv.
filename_A = sprintf('A_%d_%d', N, CONV_ITER_LP);
filename_B = sprintf('B_%d_%d', N, CONV_ITER_LP);
filename_PIV = sprintf('PIV_%d_%d', N, CONV_ITER_LP);
filename_LOGP=sprintf('LOGP_%d_%d', N, CONV_ITER_LP);

%Create the text files

```

```

dlmwrite(filename_A, A, '&');
dlmwrite(filename_B, B', '&');
dlmwrite(filename_PIV, piv, '&');

%Create the LOGP plot.
h=plot(MODEL_LOGPROB(:,2:CONV_ITER_LP)*1e-4);
saveas(h,filename_LOGP,'eps');
saveas(h,filename_LOGP,'fig');

end
end

if (ITER==1)
    %Create filename for final A,B,piv.
    filename_A = sprintf('A_%d_%d', N, ITER);
    filename_B = sprintf('B_%d_%d', N, ITER);
    filename_PIV = sprintf('PIV_%d_%d', N, ITER);

    %create the text files
    dlmwrite(filename_A, A, '&');
    dlmwrite(filename_B, B', '&');
    dlmwrite(filename_PIV, piv, '&')
end
ITER=ITER+1;
oldLogProb=logProb;

end
end

```

0.2. Models to Symbols. Here we provide the code used for going from models to observations (generating text).

```

%% HMM Code (Models to Symbols)
%% ALEX DUDA
%% amduda @ illinois.edu
%% 27 April 2013

clear all;
clc;

HS=6;
%%1. We read in the A and B Matrices.

```

```

Ac = dlmread('A/6A_sum.txt');
Bc=dlmread('B/6B_sum.txt');

%%2. We read in the corresponding symbols for B matrix.
[numData, textData, rawData]=xlsread('B/6B_char.csv');
Bc_sym=textData;
nStates=size(Bc_sym,2);
nSymbols=size(Bc_sym,1);

MAX_ITER=17340; %the length of the obs seq.
ITER=1;

%% 3. We find a hidden state containing #
FFsp=0;
i=1;
while i<(nStates+1) && (FFsp==0)
    if strcmp(Bc_sym(1,i), '#')
        currState=i;
        FFsp=1;
    end
    i=i+1;
end

GenTEXT='#';
StateSeq=currState;

for ITER=1:MAX_ITER

%4. Beginning at the current state, we determine which state to go to next.
num=rand(1);
currState_F=0;
if (num>=0)&&(num<=Ac(currState,1))
    currState=1 ;
else
    for i=2:nStates
        if (num>Ac(currState,i-1))&&(num<=Ac(currState,i))&&(currState_F==0)
            currState=i;
            currState_F=1;
        end
    end
end

%5. Given the current state, we determine which symbol to generate next.
num=rand(1);

```

```

currSymb_F=0;
if (num>=0) && (num<=Bc(1, currState))
    currSymb=Bc_sym{1, currState};
else
    for i=2:nSymbols
        if (num>Bc(i-1, currState)) && (num<=Bc(i, currState)) && (currSymb_F==0)
            currSymb=Bc_sym{i, currState};
            currSymb_F=1;
    end
end
end

%6. We concatenate the symbol to that already written.
GenTEXT=[GenTEXT, currSymb];
StateSeq=[StateSeq, currState];
%StateSeq
ITER=ITER+1;
end
GenTEXT_asci=uint16(GenTEXT);
for i=1:size(GenTEXT,2)
    if GenTEXT_asci(i)==35
        GenTEXT_asci(i)=32;
    end

    if GenTEXT_asci(i)==73
        GenTEXT_asci(i)=105;
    end
    i=i+1;
end
GenTEXT_proc=char(GenTEXT_asci);
filename_TEXT = sprintf('GenTEXT_%d', HS);
dlmwrite(filename_TEXT, GenTEXT, '');
filename_TEXT = sprintf('GenTEXT_proc_%d', HS);
dlmwrite(filename_TEXT, GenTEXT_proc, '');

```