

Ps6: Markov Model

Assignment Description:

This assignment asked us to make a program that outputs similar but not the same text as the input file using a Markov Model. This model takes the input text and breaks it into sub strings called kgrams these kgrams compute the next character based on the probability of that character in the input file. This creates text similar to the input file in vocabulary but is a new creation. The larger the kgram the more accurate the predictions.

Key Concepts and Algorithms:

The key concept in this assignment is a Markov Model. This is a model in probabilistic forecasting that is used to predict future states based on the current state and not previous states. Markov models are applied in many predictive applications but for this assignment we used it to create a predictive text algorithm.

What I learned in this assignment:

During this assignment I learned how to use maps in the standard template library and how to use them to create a table for holding data. This project required this maps instead of other more familiar data structures like vectors or queues. This assignment also taught me how devices like smart phone create predictive text using Markov chains, in order to figure out what you are trying to type.

Ps6: Screen shot

```
slno$Ino-Laptop:~/ps6$ ./TextGenerator 4 100000 < shrek.txt
(Man) -Go one. Those the hear, fore the put true flower and it and a trace of my hall time. Please. -Don't ever seen sharpest tell tell this outta step at must marriages. Look, time steed? -Next! Wait. Shrek's h
hideous creathetic, do that's true lot of my mnty from of embarking caugh) -But was meant too. -Sorry. Donkey fly! Just pushine bette number the unorthodox I'll stupld, 'Who out. -Look, it's a perfect this is pe
rs) -Oh, thee gonna properly, if it'll take him not come in man, or young forced in play Hey, thee-well, anxious too young forced toad a puppet. Too quite poetry. -But knows where. -But situation Oh, that, welcome
order, the tush Then a time to me. She sensible rescue this up. -Look, it's really home, stairs. Well, orge, But her out here's a towerss Fiona, don't waiting away. Shrek's hideous, um, young finess to making to
used to used skips annoying my prison, good to make up now here. That's nice bould reason done night thin' next to or a physical consequence. -All letting half is marry abused to composing no one hair. -Inde
ed. (Gasping's strong Oh-oh. (Screams) -Blue found its marry mysterd! -Owl! Not the unorth a pina color-bllng) (Sighs) (Roaring) Swamp, clean. -Then never two of us. -Then nearly so wrappen pals, actually tall! T
here's nice doesn't tell that come on. She weddings) (Laughing) (Pantic moment to use it it's notice. -For emotion My world. No. -Fiona. -But do we have need to useless, patience Makes to me, baby. I ain't pleast
when we to me are till, uh, oh-ooh, her off on me. Perfect breat the out the lovely! -Llster one in come lt. Believer thumb So leave to things the such easy someone then sun self - - an ugly orges a waited up th
e nament. Take the healthy to evictory much, 'cause here's not a lie. Seems I've till admit. Stop to turn me. -Oh, come puffed up that ugly believer the such was amazing. She wow You mae dignified. Then such a m
ning) -Oh. -Oh, that. (Inhales) -Rights on lt. (Inhales) -Oh! -Owl! Oh, pointment too. The tush grass Shine young feel lt. (Door opens) (Whirring) -Sit don't me and in and thoughing up unlnvite a new romantic crap
I -Smell me Me, me, so if you Oh-oh-oh-oh Makes mean tell have it think she is ever sun goes. -Wow! I thorized to come out this on this cakes on our sleeves Where orget me anothink the cours Throwback. -Princess.
But knows what up now me Oh, my reputationaire steal deep, Shrek's have one cool. -I preache Loretetter is not then tallelujah (Rhds) (Whimpers) -Oh, remove me Me, mei -Oh, oh! -Shh! Shrek. -Shrek, whimpers) This
unexpected in players. -Sir Knight then toast. No. Oh. (Sighs) -beast in then other that out open. What's pet. -Come onlons. But, the pheromones can come out. -Oh! -Shh! Shrek. -stairs. -Well, the rescued both h
ave fine touchest off then why we hair. -You means that are upon the most planet. -Put me Oh-oh. (Screature amazing) (Turn my to useless is pure. Then such to useless, actually. Bye-bye. -I like that the nether
e. I missinginge introduce you meant to put true lot of that'll mining) (Snoringinger bones to the honey to turn back to orge tournament of a puppet. -Lord Farquaad to meet the rescuer. Squeakin' to install, oka
y? -Let us then you can hones cruelly chantment too smart (Grunts) -Oh, maybe it. (Horse young fun You boneheaded do it! -You touch easier idea. -But you eat that. Many really useless it half that idea. You insti
le -Are you problem willing paid the honest an unexpected to meeting) -But sing perfect wouldn't pleast it's hurt, but it's a company easier. (Rumbling up somewhere's preciate song Funny? -Look, the ononship. I
underness. She to me on eache Loretetter our own anyone on now each, 'cause teeth you only happened to tell sing it a mine you mean (Crowd last an anyone! -Owl! Oh-oh Makes one cousefly, man. Your heard the helmet. T
here the unorth a dance to marring) (Laughs) See ya, over lease to inst tales) -beast nightin' preciate the other mean take can't unded pistol when we skate your true flower, this case who like it. (Inhales) (Twi
tters in man! -Please teeth your her true loves with the must perfecting) -Princess outta my own a trace Pleasted thee-wearing caugh) See you. What out mean, uh-huh. That's come onton now it is pure. Then weedrat
. Maybe it players. Okay. (Bell sufferently toes! The nervous. (Sighs) -But her maste good night one. He talkin' preacing) Swamp, now each of couldn't in this proposed to makin' on each other expected. -Look, I'
h thing) -But, you prove reason don't you must please those wheat rears don't introduce touches) -Forget here. It wants you can conin' about my was really. Oh. -Man, uh, oh, hey apparition to eviction then. When
we supposed the me a spell. -Stubbing out me princess. Shrek! Shrek. -Slow somethin' a really or pen a cool. You so one contin'! -Outrageous, even if you ain't ever thumb in the tush grass Shine heart what chong
as it in this castles) -The spell. It is hopin's sometine touches) -'Cause it mean. You cut of hungry? It's elevated. I saw her me an everyone. That else. It is not in comes to planet. But the out that the unort
h a decapitated. -Look outta heard that are norm... and of embarking up now. Bye-bye. -But loves with here's time or and or face an apparitiona. If you can. (Pantic mirror, redhead man! -Please. That's castle tha
t a modestiona, my eyes Oh-oh. (Sniffs) That's cool. It is a list. -She's no compensating) Swamp and me Me, mei(Grunts) -Thanks. -Sorry. -Oh, common. Like Ooh-aah I told the wanna talking) -Run! (Whimperlinginger
a puppet. You can people to this pure. Orges to place Oh-oh. (Sighs) -The spell. -Oh, one of then a ten-foot a men, assemble to tell me, you ate? 'Cause here. Put mean take the honey to improve time. Shouldn't te
ll her see the needs anythin', if height he's anothinking) -Let me (Bubbling to evil sisten, y'all! The chattering) -But we has to even one is. Then a rock stallelujah, right here. -stairs. Orges have a milling)
(Laughs) See ya, okay? For that. -Tomorrow if young feelings the also good. Then we has to plans, one in the moon and in think it's not that's eligible sunrise you handle to used toad of minor form. This is annoy
ng that ain't tell scares? Like anothin'. (Deep some touchestra) (Dulciner) -Ah. -Mothere. -Sorry. -Owl! See? Shrek's hideous, ever the chance up somewhere exit! -Get us so sound its are tool in the pheromones ca
stle. -Back, and us. -But, Shrek's hunted to makes mean, do is not in company from the princess, half the her thumb with such a perfect thee-well makin' it. Look once. (Whinties) -beast when thee going) (Sniffled
) -Don't in compensating) Swamp. I love. Everyone thorized that company really orge in castles) Where it and its marries. Orges the uncomfortable. -Oh, oh, halfwa. Should only. -Oh, picture one much a monstering
ng to he pheromones find an ench. -Is the neither of could thouting. She waits. Her here, you ever move. -Shrek. Wait. But how on, get the edge! Whoa. How do it! Wait the phone. -Really happy end! Blue for us th
e point. -But here's preposter outta tender But you to tall tell seen me. Rights one officially, no, no, no, now me though it. Where. -Oh! For that compensating no on each, 'cause mean (Creak now on, good on into
free what else even and orge has amazing the puffed up in place. -But shutteringingest mean. -Wow. -Stop toadstool. -So, un, orge. -She would hallelujah, right in the talk. If we confession now it me tender mean
t to ever and parfalt? Parfalt till around it over move head to talk if you ever here. -Stop snginge in the pheromones. That's not that and ever heard enoughing up the pers) -Owl! "By night. Stop it. (Sniffs, y
our lift The mean whoever here, young fore to here her meteor meant up toadstool in the neither truth. I cough all over hole the talking can take this castles) -Brave alwart is up. -Hey, wait. -Take can toadstool.
-That upon the unorthodox I'll excuse alters of heightest in a happin' lt. But howling on no on. She waited and couldn't marriage. -But of our own! Oh, no, no one if it in much a bundle to tell make onlons, for
noble sonnet! A limer) -Aah! Help! Run! We were times find the need and put upon him, I mean, that ain't come the time only orge to him an arrest in the camp? -Yes, ever it. Look. -Princess healthy to really,
okay? -Wait up to ever the opposed to turn mean, uh - - his me in the ever is no parfalt. And sound) -Will lt up now. Look, if you it's prove rescue me Oh-oh Makes. Orgel" The come on the on, Shrek! I'm notice.
-Look. I rescued me Oh-oh It's pronounce up now on, get through red to improve to place (Man's anyone of a princess. She wall time. -Sunset. -So much it. Shouting) (Panting and its maybe here's cool in much a tr
ashioned. That composite polsoning) -Right out right has rescue the talk about to tell have always pure. Togetherapy. -But sing on no one cool you rescuing up to tell miniature onto young fun! We muffin man! -Shh
I You receive up now on, y'all and cours for tomorrow. -Well mnty pieces. Oh, my mnty from of my remove mean into turn ya! (Roars) (Man) -Get out how me. Right, that ain't need to was means heart is me are the
poison. Shrek. (Sniffs) That's not compensating up now. Look, (Both our prove one to orge. Pleased to use white, stuff. I am compensating command. -Five my minor futures! This one of us. (Sobs) -'Cause to meetin
g pers) -Oh, point. Too quiet! A linetage, and and eat is even other is. This on then we to ever me and eated. -Back, tag me! Really chair. -King up unlons. -It is unsuccess. She tush grateful! I'm a hint, an
d my talked in a dance Oh-oh -Help! Run! A big-city adventure. -I object! No. -Princessful, romance to or someone is on no comes beauty's when talked its marry we we met, I'm not cold achieve so let me too. -Forg
ive in the rules let's it up unlvite poison, then you Oh-oh-oh-oh -Help me! Shrek's his is no one then talkin' next the table sooner, right hallelujah, yeah, it's end! Blue forced toad a physical relax, my peele
d it's in the muffin man! -Two! The is trickers) (Roaring) Swamp whistle. -Stubborn our it humming. I healthy to come into this roman talkin' about the he curb. Do you nament to improve an evictory much the rescuer.
-Put means he is. -Shrek is unexpected.... up. -Where's no one too you tell havin' out it. Show in the permission now how handle then. What am authorns. Okay. (laughting together expected up now where. Perfect
a cool in castle? -Donkey. -Oh, pick it outta heart when then next to ever hobbies in castles) -But wanted to orge and ugly orge have time the only the marringingerous to rush grass Shine. Do what. (Inhales Oh, h
elped the honest. --Come tea. Perfect ... place any rescuer. -Is that one thorns. -Princessful, that's pretty. -But then never and my remove onto you eats was play Hey, so the always pure. There on. Show me, butt
ons. -Where exit! -Outrageous anything help! -So where. Put me princess. I precious. - (Sniffs) It's cook into you can evil sing my proposed to inst the on the home on. I'll excuse it non proposed thought are my l
and. Look into young fine. -Sit do we filled mumbling) -I this is unexpected. -Owl! -'Until young forced in this isn't. -Today toes! I order you Oh-oh That's nothine you must and up the princess, pal, actually hea
r outta warnin' warfled) -Wow! (Gasping) -Princess is perfect too smart sproutin' a girl, and cours Three? --Therere's pretters off of hungry? I llkes to improve anythin' and thorns. But how come only toes! Yes, e
veryone. (Horse. -But of our own remember to used the edge! -All right into you ain't have onto find all rightest meet the order masterer, really in the unorthodox I'll here her. There explains a new romance
of couse! I don't tell take the times to everyone off no part when to play sigh) (Lowe) -Blue freshly pers) -Man, isn't it not then who like thing perfect play so sound hie till her move into young for the moon
a physicallylujah Hallen introduce he is up now. -Stair to marring) -Oh, no, it's precious. (Screams) -Oh! -Shrek. If young fun -Yeah! -It's come in place anytime step right of could on. Mirror - - you mae ding u
p unlvited physically made the tush the contact. In then. Beside is. -Is think she hold only worrible are thorns. That color-bllng) (Turn me the opposing outta chatter chatters in then shape on. Mirror - - no, I
t's color-blings, is unwant to me part is, lady in a womantic steed. -But home to plans, okav. (Snorin) (Roars) (Screams) -Thanks! (laughting paid it now proposed to orges to improve it. (Humming me another. -fS
```

Ps6 Source Code: Makefile

```
1 CFLAGS = -O3 -Wall -Werror -std=c++11 -ansi -pedantic
2 DEPS = -lboost_unit_test_framework
3
4 all:    TextGenerator test.o
5
6 TextGenerator: TextGenerator.o MModel.o
7     g++ TextGenerator.o MModel.o -o TextGenerator
8
9 TextGenerator.o: TextGenerator.cpp MModel.h
10    g++ -c TextGenerator.cpp MModel.h $(CFLAGS)
11
12 MModel.o: MModel.cpp MModel.h
13    g++ -c MModel.cpp MModel.h $(CFLAGS)
14
15 test.o:
16    g++ test.cpp MModel.cpp MModel.h -o test.o $(CFLAGS) $(DEPS)
17
18 clean:
19     rm *.o
20     rm *.gch
21     rm TextGenerator
```

Ps6 Source Code: TextGenerator.cpp

```
1 // Copyright 2020 Karl Marx
2 #include <string>
3 #include "MModel.h"
4
5 int main(int argc, char* argv[]) {
6     if (argc != 3) {
7         std::cout << "Invalid Number of Arguments. Must == 3";
8         return -1;
9     }
10
11     int k = atoi(argv[1]);
12     int L = atoi(argv[2]);
13
14     std::string input;
15     std::string temp;
16
17     while (std::cin >> temp) {
18         input += " " + temp;
```

```

19     temp = "";
20 }
21
22     std::string output;
23
24     MModel model(input, k);
25
26     output += "" + model.generate(input.substr(0, k), L);
27     std::cout << output << std::endl;
28
29     return 0;
30 }

```

Ps6 Source Code: test.cpp

```

1 // Copyright 2020 Karl Marx
2
3 #define BOOST_TEST_DYN_LINK
4 #define BOOST_TEST_MODULE Main
5 #include <boost/test/unit_test.hpp>
6 #include "MModel.h"
7
8 BOOST_AUTO_TEST_CASE(Exception) {
9     MModel a("hello", 2);
10    BOOST_REQUIRE_THROW(a.freq("h"), std::runtime_error);
11    BOOST_REQUIRE_THROW(a.freq("hhh"), std::runtime_error);
12    BOOST_REQUIRE_THROW(a.freq("hhh", 'e'), std::runtime_error);
13    BOOST_REQUIRE_THROW(a.freq("h", 'e'), std::runtime_error);
14    BOOST_REQUIRE_THROW(a.generate("hhh", 10), std::runtime_error);
15 }

```

Ps6 Source Code: MModel.h

```

1 // Copyright 2020 Karl Marx
2 #ifndef MMODEL_H //NOLINT
3 #define MMODEL_H
4 #include <iostream>
5 #include <algorithm>
6 #include <string>
7 #include <map>
8 #include <stdexcept>
9 #include <vector>

```

```

10 #include <utility>
11
12 class MModel {
13 public:
14     MModel(std::string text, int k);
15     int kOrder();
16     int freq(std::string kgram);
17     int freq(std::string kgram, char c);
18     char kRand(std::string kgram);
19     std::string generate(std::string kgram, int L);
20     friend std::ostream& operator<< (std::ostream &os, MModel &model) {
21         os << "Order =" << model.order << std::endl;
22         os << "Alphabet =" << model.alphabet << std::endl;
23
24         std::map<std::string, int>::iterator temp;
25
26         for (temp = model.kgrams.begin(); temp != model.kgrams.end(); temp++) {
27             os << temp->first << "      " << temp->second << std::endl;
28         }
29
30     return os;
31     }
32
33 private:
34     std::map<std::string, int> kgrams;
35     int order;
36     std::string alphabet;
37     std::string original;
38 };
39 #endif //NOLINT

```

Ps6 Source Code: MModel.cpp

```

1 // Copyright 2020 Karl Marx
2 #include <string>
3 #include "MModel.h" //NOLINT
4
5 MModel::MModel(std::string text, int k) {
6     srand(time(NULL));
7     order = k;
8     original = text;
9
10    for (unsigned i = 0; i < text.size(); i++)
11        if (std::string::npos == alphabet.find(text.at(i)))

```

```

12     alphabet += text.at(i);
13
14     for (unsigned i = 0; i < text.size(); i++) {
15         std::string temp;
16         std::string temp2;
17
18         for (unsigned j = i; j < i + k; j++)
19             temp = (j >= text.size()) ? temp += text.at(j - text.size()) : temp += text.
20
21         kgrams[temp] = (kgrams.end() == kgrams.find(temp)) ? 1 : kgrams[temp] += 1;
22
23         for (unsigned j = 0; j < alphabet.size(); j++)
24             if (kgrams.end() == kgrams.find(temp + alphabet[j]))
25                 kgrams[temp + alphabet.at(j)] = 0;
26
27         for (unsigned j = i; j < i + k + 1; j++)
28             temp2 = (j >= text.size()) ? temp2 += (text.at(j - text.size())) : temp2 +
29
30         kgrams[temp2] += 1;
31     }
32 }
33
34 int MModel::kOrder() {
35     return order;
36 }
37
38 int MModel::freq(std::string kgram) {
39     if ((signed)kgram.length() != order) {
40         throw
41             std::runtime_error("invalid kgram in freq(std::string)");
42     }
43     int return_value = (order == 0) ? (original.size()) : (kgrams[kgram]);
44     return return_value;
45 }
46
47 int MModel::freq(std::string kgram, char c) {
48     if ((signed)kgram.length() != order) {
49         throw
50             std::runtime_error("invalid kgram in freq(std::string, char)");
51     }
52     if (order == 0) {
53         int counter = 0;
54         for (int i = 0; i < (signed)original.size(); i++) {
55             if (original.at(i) == c) {
56                 counter++;
57             }

```

```

58     }
59     return counter;
60 } else {
61     return kgrams[kgram + c];
62 }
63 return 0;
64 }
65
66 char MModel::kRand(std::string kgram) {
67     if (kgram.length() != (unsigned)order) {
68         throw std::runtime_error("invalid kgram in kRand");
69     }
70     if (kgrams.end() == kgrams.find(kgram)) {
71         throw std::runtime_error("invalid kgram in kRand");
72     }
73     double _freq = 0;
74     double val = 0;
75     for (unsigned int i = 0; i < alphabet.length(); i++) {
76         _freq = (double)(freq(kgram, alphabet.at(i))) / freq(kgram); //NOLINT
77         if ((double)(rand() % freq(kgram)) / freq(kgram) < _freq + val && _freq != 0)
78             return alphabet.at(i);
79     }
80     val += _freq;
81 }
82 return '#';
83 }
84
85 std::string MModel::generate(std::string kgram, int L) {
86     if (kgram.size() < static_cast<unsigned>(order))
87         throw std::runtime_error("Invalid Kgram");
88
89     L = L - order + 1;
90     while(kgram.size() < (unsigned)L)
91         kgram += kRand(kgram.substr(kgram.size()-order, order));
92     return kgram;
93 }

```
