1. Time complexity for SolverTree construction: O(4n)  
   Time complexity for searching the dictionary: O(4n)  
   Time complexity for entering n digits: O(16n)
2. Exhaustive search (or brute-force search) finds all possible outcomes for a solution by checking every possible input value. The solverTree falls into exhaustive search when finding possible combinations of letters from an input and then checking them against the dictionary (ie. 333 is entered. The possible combinations are ddd, dde, ddf, ded, dee, def, dfd, dfe, dff, edd, ede, edf, eed, eee, eef, efd, efe, eff, fdd, fde, fdf, fed, fee, fef, ffd, ffe, fff. The program checks each one against the dictionary instead of looking to see if the first two or so digits exist in the dictionary in the first place.)
3. Branch and bound checks to see if a possible solution is better than the most efficient solution found thus far. If a solution is deemed to be less efficient, the algorithm continues on to the next possible solution.
4. Yes, implementing branch and bound would make the algorithm more efficient. Checking to see if the first two or so letters for each combination of digits exist in the dictionary would dramatically increase performance, especially for longer words (ie. 4354267837 / helicopter).  
     
   With an input of 4354267837, the program would first determine if any word exists in the dictionary with the first letter corresponding to the first digit (g, h, i). If so, it would check the dictionary for words beginning with combinations of the first two letters. If none are found, it would no longer check for words with those first two letters. This would continue for the rest of the input.  
     
   First digit: 4, possible letters g, h, i. Are there any words in the dictionary that start with any of these letters? If so, continue. If not, return.  
   Second digit: 3, possible letters d, e, f. Are there words that start with gd? If not, do not continue searches beginning with gd. ge? gf? … he? There are words starting with he in the dictionary, so that becomes a possible solution.  
   This would continue for the rest of the digits, excluding any search for words beginning with gd, gf, etc.

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

a

Numbers entered must be 2-9 and cannot be letters or special characters

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

!

Numbers entered must be 2-9 and cannot be letters or special characters

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

0

Numbers entered must be 2-9 and cannot be letters or special characters

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

1

Numbers entered must be 2-9 and cannot be letters or special characters

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

35

Testing against Hashtable...

dj

ek

el

fk

fl

Testing against Prefix Tree...

dj

ek

el

fk

fl

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

465

Testing against Hashtable...

gol

ink

inl

Testing against Prefix Tree...

gol

ink

inl

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

321

Numbers entered must be 2-9 and cannot be letters or special characters

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

654

Testing against Hashtable...

okh

Testing against Prefix Tree...

okh

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

exit

-------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

645

Testing against Hashtable...

nhl

oil

Testing against Prefix Tree...

nhl

oil

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

328

Testing against Hashtable...

dat

eat

ebt

fat

Testing against Prefix Tree...

dat

eat

ebt

fat

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

65453

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

5423

Testing against Hashtable...

jibe

Testing against Prefix Tree...

jibe

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

98564

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

exit

-------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

98753

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

57446

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

325

Testing against Hashtable...

dal

Testing against Prefix Tree...

dal

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

4564

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

6546

Testing against Hashtable...

mjin

Testing against Prefix Tree...

mjin

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

4354267837

Testing against Hashtable...

helicopter

Testing against Prefix Tree...

helicopter

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

43554

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

43556

Testing against Hashtable...

hello

Testing against Prefix Tree...

hello

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

exit

-------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

4654

Testing against Hashtable...

inli

Testing against Prefix Tree...

inli

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

6565

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

3542

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

23548

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

8795

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

897

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

5564

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

56

Testing against Hashtable...

km

ko

lo

Testing against Prefix Tree...

km

ko

lo

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

3524

Testing against Hashtable...

flag

Testing against Prefix Tree...

flag

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

42

Testing against Hashtable...

ga

ha

ia

ib

ic

Testing against Prefix Tree...

ga

ha

ia

ib

ic

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

exit

-------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

7864

Testing against Hashtable...

rung

sung

Testing against Prefix Tree...

rung

sung

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

9865

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

358

Testing against Hashtable...

flu

Testing against Prefix Tree...

flu

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

6848

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

9875

Testing against Hashtable...

Testing against Prefix Tree...

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

986

Testing against Hashtable...

zum

Testing against Prefix Tree...

zum

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

936

Testing against Hashtable...

yen

Testing against Prefix Tree...

yen

Enter in keypad numbers or type 'exit'

(Example: 23456)

KeyPad:

2 = (a b c)

3 = (d e f)

4 = (g h i)

5 = (j k l)

6 = (m n o)

7 = (p q r s)

8 = (t u v)

9 = (w x y z)

--->

Exit

1. Clark Rabe, Jacob Berger  
   Did not attempt extra credit.