Natural Language Processing for Spoken Dialog Systems

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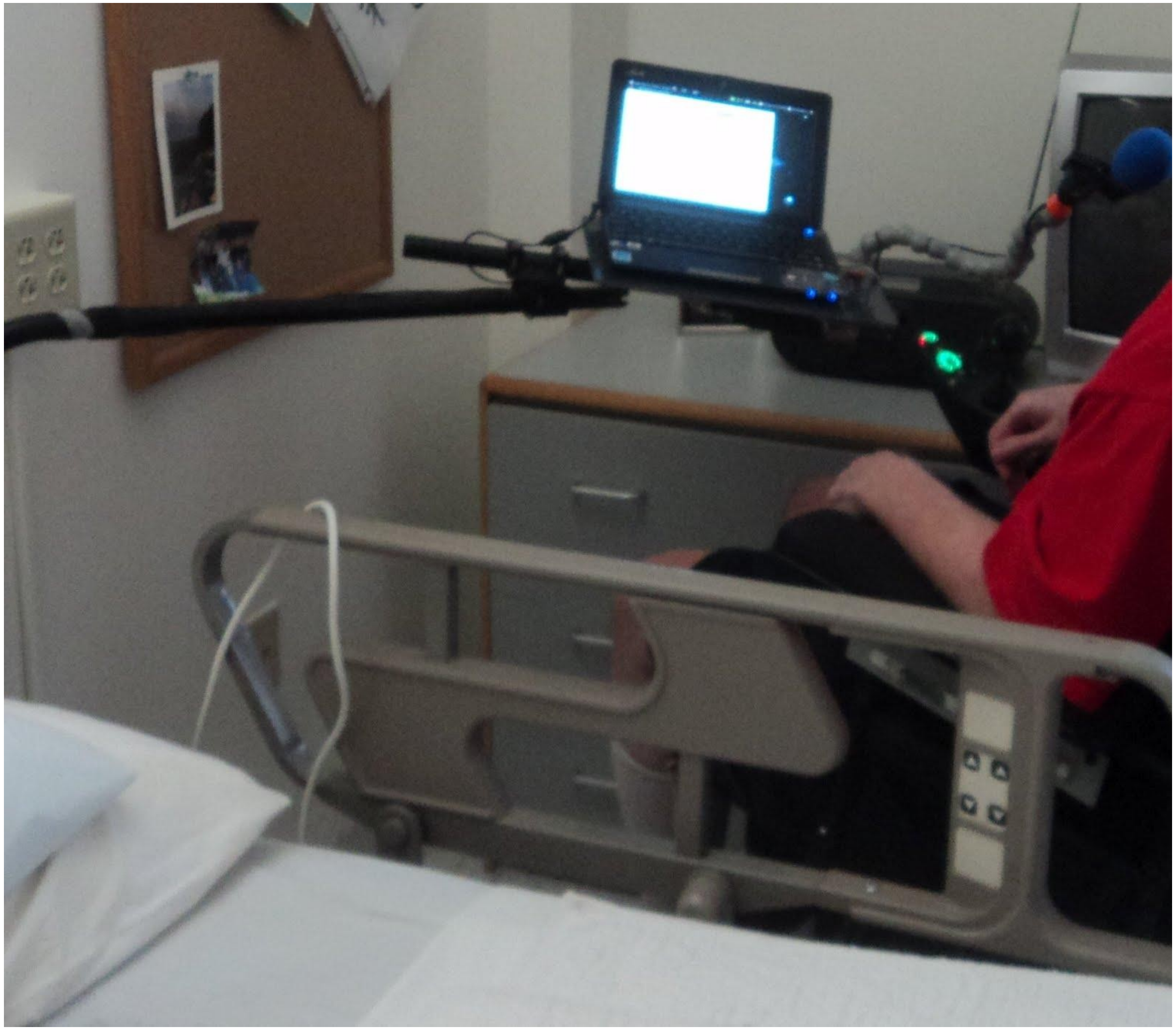
High Level Introduction

- Assistive technology
  - Helps disabled people
- The Boston Home
  - Nursing care facility
  - Robotic Wheelchair
    - Works on its spoken dialog system
- Spoken dialog system makes things easier for the residents
  - Can still be improved

Wheelchair Image



Introduction

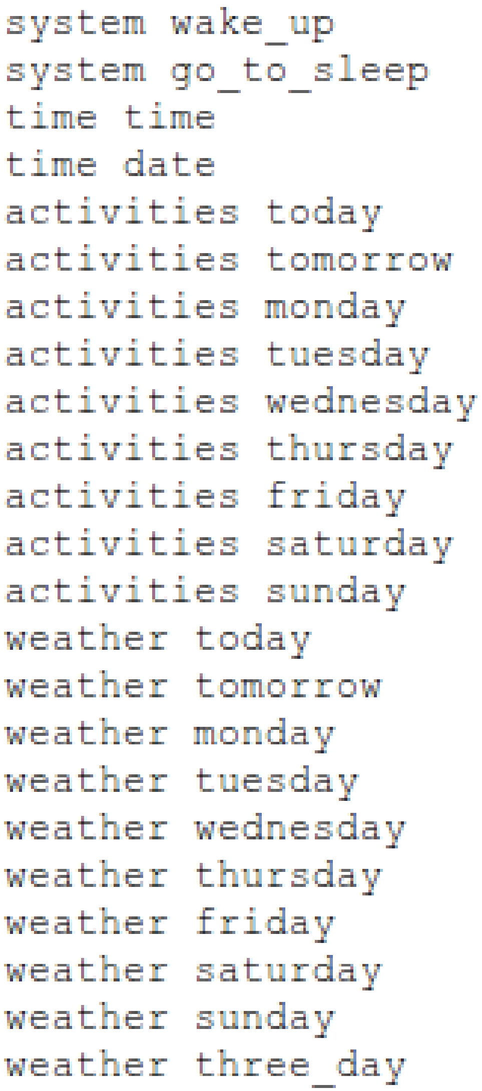
- Spoken dialog system has two parts
    - Speech Recognition
    - Natural Language Processing (NLP)
- Goal of the project: Improve both parts of the dialog system using natural language processing

What can I help you with?

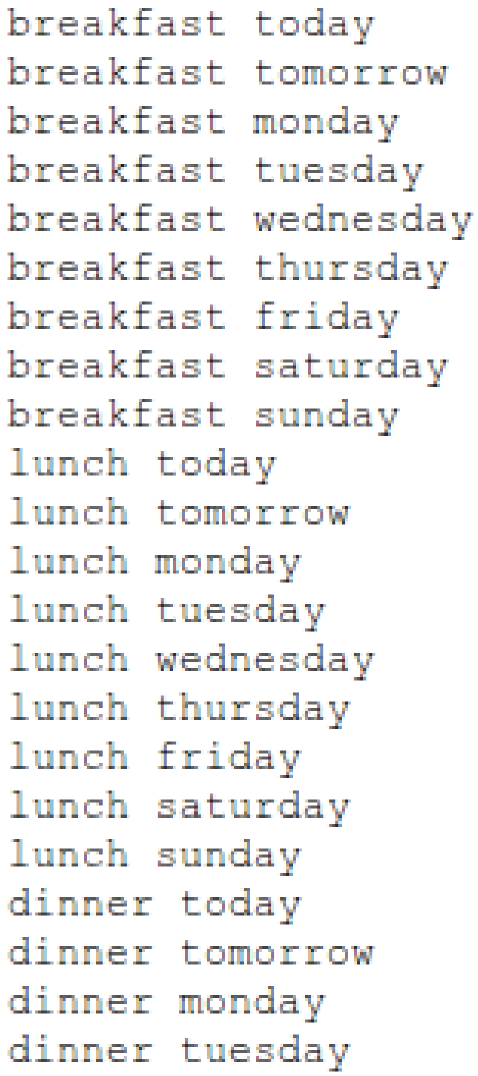
Dialog System

- Has certain actions that it can make (categories)
- Shows the weather, meals of the day, activities for the day, etc.
- Categories are made of two parts (sub-categories), some categories share a part

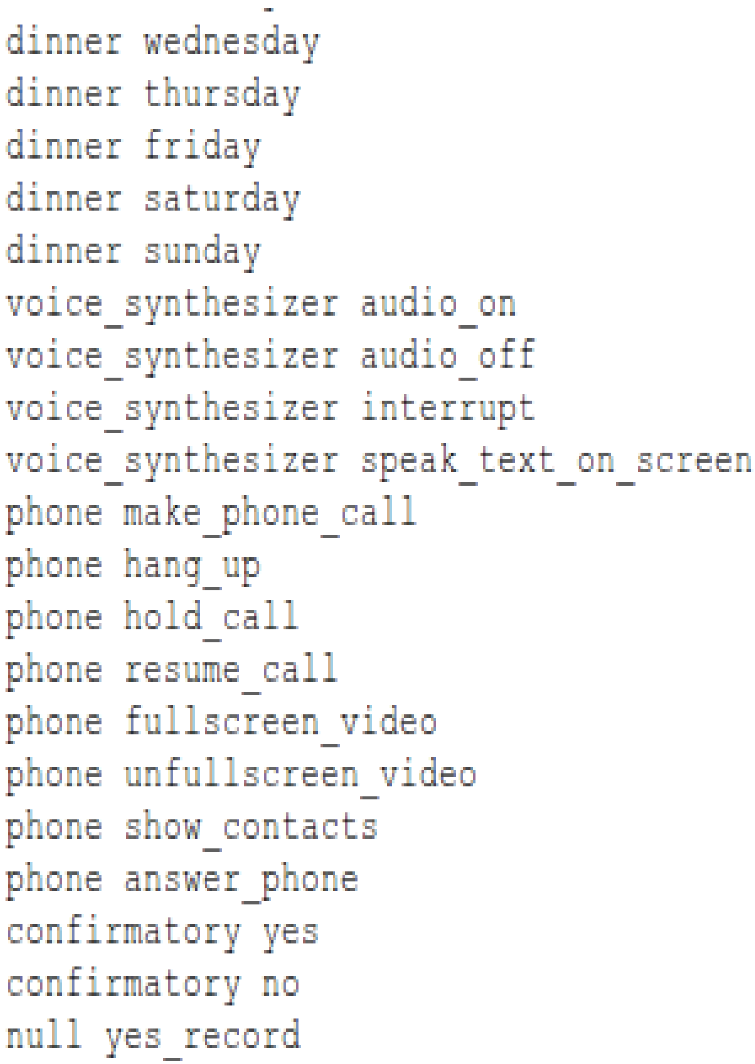
List of Dialog System Categories



```
system wake_up
system go_to_sleep
time time
time date
activities today
activities tomorrow
activities monday
activities tuesday
activities wednesday
activities thursday
activities friday
activities saturday
activities sunday
weather today
weather tomorrow
weather monday
weather tuesday
weather wednesday
weather thursday
weather friday
weather saturday
weather sunday
weather three_day
```

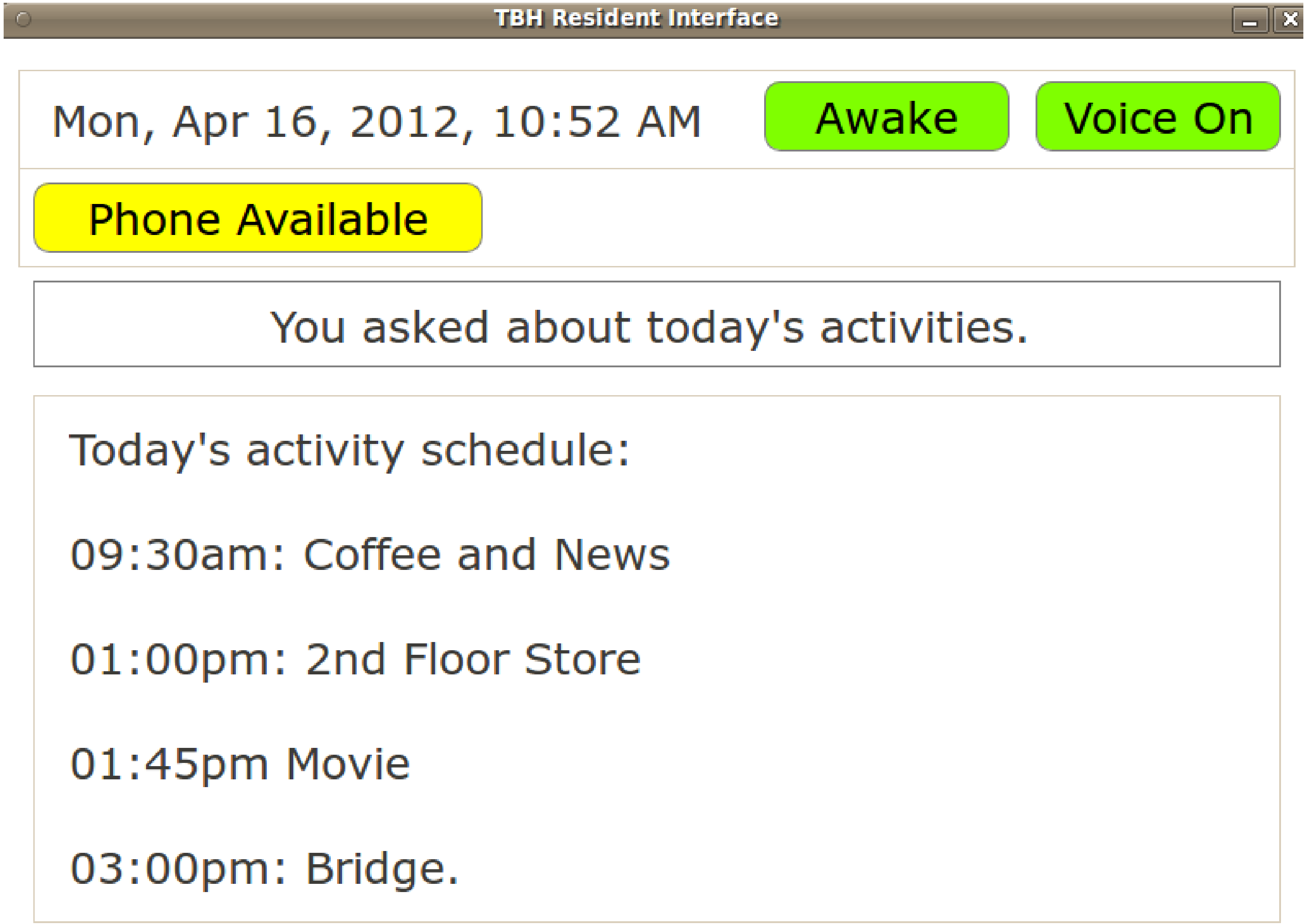


```
breakfast today
breakfast tomorrow
breakfast monday
breakfast tuesday
breakfast wednesday
breakfast thursday
breakfast friday
breakfast saturday
breakfast sunday
lunch today
lunch tomorrow
lunch monday
lunch tuesday
lunch wednesday
lunch thursday
lunch friday
lunch saturday
lunch sunday
dinner today
dinner tomorrow
dinner monday
dinner tuesday
```



```
dinner wednesday
dinner thursday
dinner friday
dinner saturday
dinner sunday
voice_synthesizer audio_on
voice_synthesizer audio_off
voice_synthesizer interrupt
voice_synthesizer speak_text_on_screen
phone make_phone_call
phone hang_up
phone hold_call
phone resume_call
phone fullscreen_video
phone unfullscreen_video
phone show_contacts
phone answer_phone
confirmatory yes
confirmatory no
null yes_record
```

Dialog System GUI



Mon, Apr 16, 2012, 10:52 AM

You asked about today's activities.

Today's activity schedule:

09:30am: Coffee and News

01:00pm: 2nd Floor Store

01:45pm Movie

03:00pm: Bridge.

Part 1: Applying NLP to Speech Recognition

- Lower the error rate of the speech recognition with NLP
- Obtain NLP data from sentences
- Use data to classify it as "correctly transcribed" or "incorrectly transcribed"

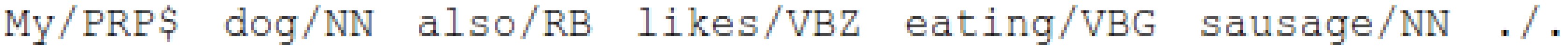
Training Set

- Training set was needed to train the classifier
- The Boston Home residents created this set
    - Asked for a category
    - Marked off whether the transcription was correct

Extracting NLP Features

- Classifier was trained with NLP features
- Used the Stanford Parser to extract the NLP (part-of-speech) features
- Example of some features:
    - NN - Noun, singular
    - ADJP - Adjective phrase
    - PRP - Personal Pronoun

Stanford Parser Example



```
My/PRP$  dog/NN  also/RB  likes/VBZ  eating/VBG  sausage/NN  ./.
```

- PRP$ - Possessive personal pronoun
- NN - Noun singular
- RB - Adverb
- VBZ - Verb, 3rd person singular present
- VBG - Verb, present participle

Using the features with AdaBoost

- AdaBoost
  - An Adaptive Boosting algorithm
- Finds features that separate the correct and incorrect sentences the best
- Uses those features to train classifier
- Example:
  - FRAG (fragment) appeared more in incorrect sentences
  - Classifier would mark sentence down if it contained FRAG

Results of the Final Classifier

- Test set
  - Original training set was split 80-20
  - 80: Training set
  - 20: Test set

- 67.7% (+/- 2%) correct on the test set

Improving NLP in the Dialog System

- Old NLP was simple
  - Used keyword searching
  - Could not ask more natural questions
- Goal: To enable understanding of more natural phrases

Approach

- Needed to associate words like "forecast" or "rain" with "weather"
- Scanned online sources that contain relevant words in the same place
  - Wikipedia
  - Twitter
  - Amazon Mechanical Turk

WIKIPEDIA
The Free Encyclopedia

twitter

amazon mechanical turk™
Artificial Artificial Intelligence

Scanning Online Sources

- Scanned online sources for each sub-category
  - Weather, Dinner, Lunch, etc.
- Put all of these words into files
- Used different online sources to find relevant words
  - Wikipedia Articles
  - Twitter Tweets
  - Amazon Mechanical Turk Data

Online Sources

- Wikipedia
  - Sub-category was most often title
- Twitter
  - Sub-category was a word in the tweet
- Amazon Mechanical Turk
  - Users were asked to type in ways that they would ask for a category
  - Restriction: No sub-categories in the sentence
  - Example
    - Prompt: "Ask for 'weather today' without using the words 'weather' or 'today'"
    - Potential response: "What is the forecast right now?"

Using Tf*Idf for Word Association

- To find a word's most relevant sub-category tf*idf was used
- Term frequency-Inverse Document Frequency
  - Used to score how relevant a sub-category is to a word
  - Finds the best association of that word

Tf*Idf

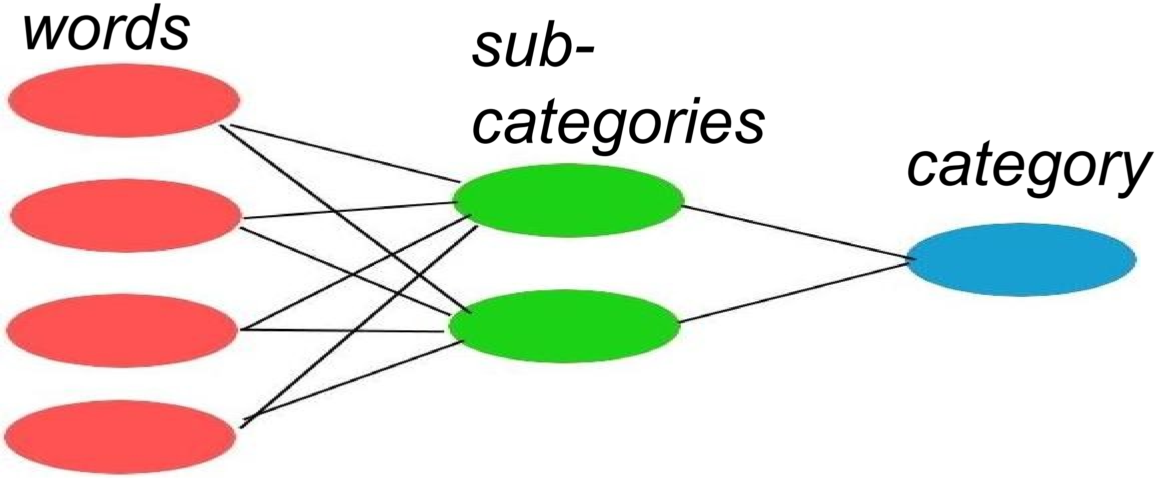
- For a word to a document in a set of documents
- Term frequency
  - Input word count divided by total word count
- Inverse document frequency
  - Takes the log_10 (total files / total files containing that word)
- Tf*Idf
  - Multiplies the tf and the idf

Tf*Idf Example

- Example: "The Brown Cow"
- "The"
    - tf - Generally high
    - Most likely all files contain this word
        - idf = log_10(1) = 0
    - tf*idf = 0
- "Brown" or "Cow"
    - tf - Smaller
    - idf - Not zero
    - tf*idf - Not zero, both have impact on total tf*idf

Categorizing an Input Sentence

- For each sub-category, tf*idf was used on each word in the input sentence
- Total tf*idf = sum of word tf*idfs
- Both sub-category scores were added to find score of the entire category



words

sub-categories

category

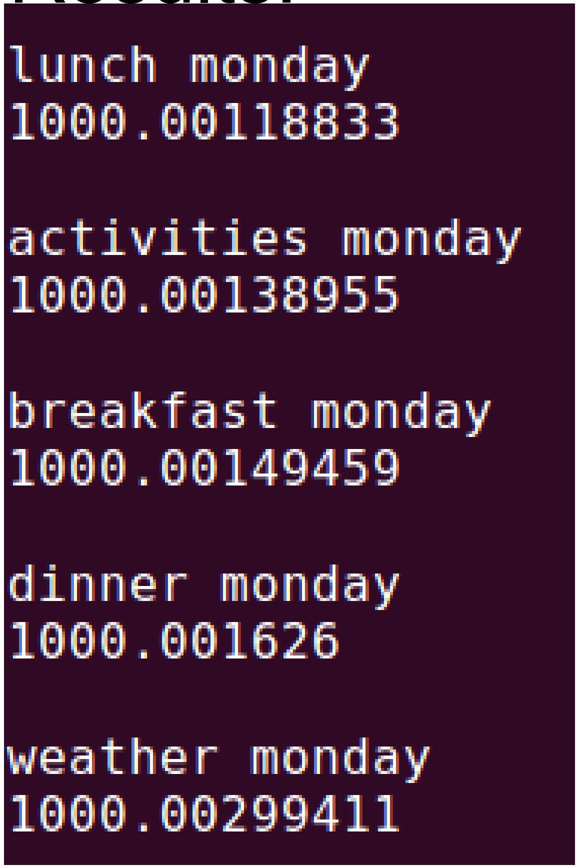
Incorporating Keyword Searching

- Phrases containing sub-categories should definitely be categorized correctly
- Used keyword searching of each sub-category
- Prioritized the keyword searching

- e.g "What is the forecast for monday?"
    - All categories containing the sub-category "monday" were considered

Example Results

- Input: "what is the forecast for monday"
- Results:



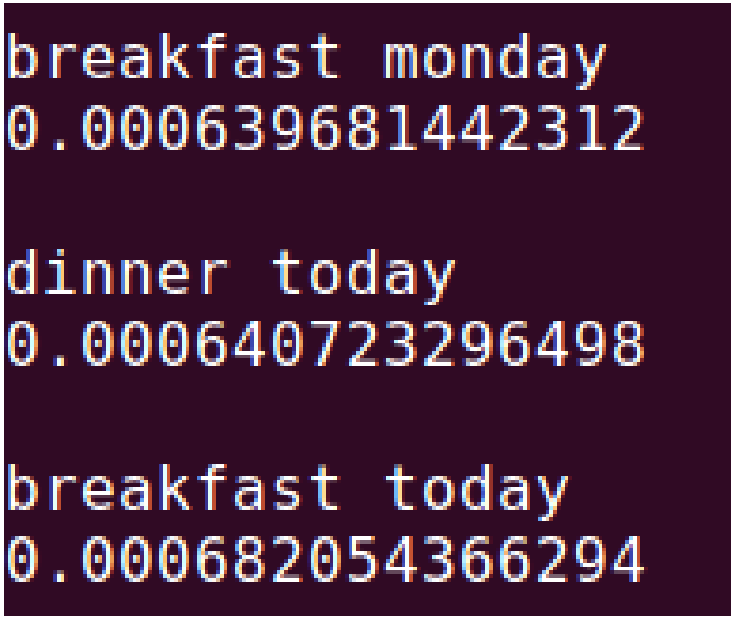
```
lunch monday
1000.00118833

activities monday
1000.00138955

breakfast monday
1000.00149459

dinner monday
1000.001626

weather monday
1000.00299411
```

Best: weather monday

(results only show top 5 categories)

Another Example

- Input: "pizza" (using Twitter)
- Results (top 3):



```
breakfast monday
0.000639681442312

dinner today
0.000640723296498

breakfast today
0.000682054366294
```

Getting Results

- Two different test sets
- My test set
  - Listed 5-10 sentences per category
  - Unbiased
  - No restrictions
- Amazon Mechanical Turk test set
  - Used the training set as a test set (80-20 split)
  - Keyword searching would perform 0% ideally

Results

(percent of correctly classified sentences in each test set)

	Keyword Searching	Wikipedia	Twitter	AMT Training Set
My Test Set	69.1	79.5	76.1	74.9
AMT Test Set	9.9	37.4	23.5	63.0

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