Speech Processing

Using Speech with Computers

Overview

- Speech vs Text
  - Same but different
- Core Speech Technologies
  - Speech Recognition
  - Speech Synthesis
  - Dialog Systems

Pronunciation Lexicon

- *List of words and their pronunciation*
  - *(“pencil” n (p eh1 n s ih l))*
  - *(“table” n (t ey1 b ax l))*
- *Need the right phoneme set*
- *Need other information*
  - *Part of speech*
  - *Lexical stress*
  - *Other information (Tone, Lexical accent …)*
  - *Syllable boundaries*

Homograph Representation

- *Must distinguish different pronunciations*
  - *(“project” n (p r aa1 jh eh k t))*
  - *(“project” v (p r ax jh eh1 k t))*
  - *(“bass” n_music (b ey1 s))*
  - *(“bass” n_fish (b ae1 s))*
- *ASR multiple pronunciations*
  - *(“route” n (r uw t))*
  - *(“route(2)” n (r aw t))*

Pronunciation of Unknown Words

- *How do you pronounce new words*
- *4% of tokens (in news) are new*
- *You can't synthesis them without pronunciations*
- *You can't recognize them without pronunciations*
- *Letter-to-Sounds rules*
- *Grapheme-to-Phoneme rules*

LTS: Hand written

- *Hand written rules*
  - *[LeftContext] X [RightContext] -> Y*
  - *e.g. Pronunciation of letter “c”*
  - *c [h r] -> k*
  - *c [h] -> ch*
  - *c [i] -> s*
  - *c -> k*

LTS: Machine Learning Techniques

- *Need an existing lexicon*
  - *Pronunciations: words and phones*
  - *But different number of letters and phones*
- *Need an alignment*
  - *Between letters and phones*
  - *checked -> ch eh k t*

LTS: alignment

- *checked -> ch eh k t*

c	*h*	*e*	*c*	*k*	*e*	*d*
ch	_	*eh*	*k*	_	_	*t*

- *Some letters go to nothing*
- *Some letters go to two phones*
  - *box -> b aa k-s*
  - *table -> t ey b ax-l -*

Find alignment automatically

- *Epsilon scattering*
  - *Find all possible alignments*
  - *Estimate p(L,P) on each alignment*
  - *Find most probable alignment*
- *Hand seed*
  - *Hand specify allowable pairs*
  - *Estimate p(L,P) on each possible alignment*
  - *Find most probable alignment*
- *Statistical Machine Translation (IBM model 1)*
  - *Estimate p(L,P) on each possible alignment*
  - *Find most probable alignment*

Not everything aligns

- *0, 1, and 2 letter cases*
  - *e -> epsilon “moved”*
  - *x -> k-s, g-z “box” “example”*
  - *e -> y-uw “askew”*
- *Some alignments aren’t sensible*
  - *dept -> d ih p aa r t m ax n t*
  - *cmu -> s iy eh m y uw*

Training LTS models

- *Use CART trees*
  - *One model for each letter*
- *Predict phone (epsilon, phone, dual phone)*
  - *From letter 3-context (and POS)*
- *# # # c h e c -> ch*
- *# # c h e c k -> _*
- *# c h e c k e -> eh*
- *c h e c k e d -> k*

LTS results

- Split lexicon into train/test 90%/10%
  - i.e. every tenth entry is extracted for testing

Lexicon	Letter Acc	Word Acc
OALD	95.80%	75.56%
CMUDICT	91.99%	57.80%
BRULEX	99.00%	93.03%
DE-CELEX	98.79%	89.38%
Thai	95.60%	68.76%

Example Tree

```
For letter V:
if (n.name is v)
    return _
    if (n.name is #)
            if (p.p.name is t)
                return f
                return v
            if (n.name is s)
                if (p.p.p.name is n)
                    return f
                    return v
                return v
```

But we need more than phones

- What about lexical stress
  - p r aa1 j eh k t -> p r aa j eh1 k t
- Two possibilities
  - A separate prediction model
  - Join model – introduce eh/eh1 (BETTER)

	LTP+S	LTPS
L no S	96.36%	96.27%
Letter	---	95.80%
W no S	76.92%	74.69%
Word	63.68%	74.56%

Does it really work

- 40K words from Time Magazine
  - 1775 (4.6%) not in OALD
  - LTS gets 70% correct (test set was 74%)

	Occurs	%
Names	1360	76.6
Unknown	351	19.8
US Spelling	57	3.2
Typos	7	0.4

Spoken Dialog Systems

- *Information giving*
  - *Flights, buses, stocks weather*
  - *Driving directions*
  - *News*
- *Information navigators*
  - *Read your mail*
  - *Search the web*
  - *Answer questions*
- *Provide personalities*
  - *Game characters (NPC), toys, robots, chatbots*
- *Speech-to-speech translation*
  - *Cross-lingual interaction*

Dialog Types

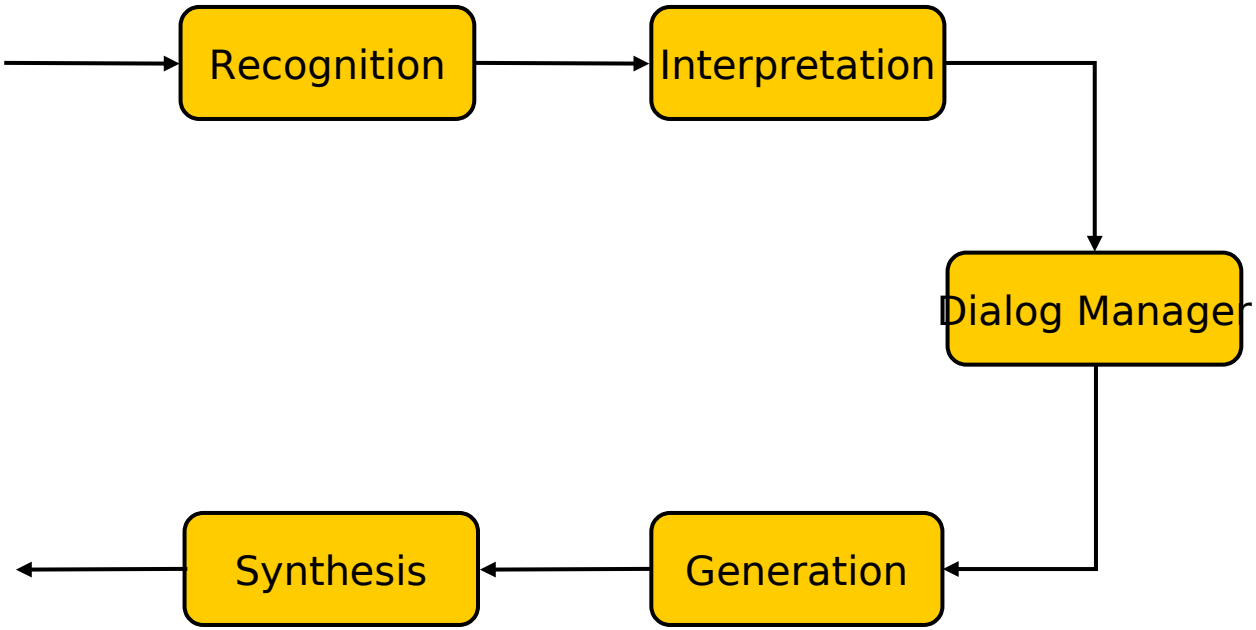
- *System initiative*
  - *Form-filling paradigm*
  - *Can switch language models at each turn*
  - *Can "know" which is likely to be said*
- *Mixed initiative*
  - *Users can go where they like*
  - *System or user can lead the discussion*
- *Classifying:*
  - *Users can say what they like*
  - *But really only "N" operations possible*
  - *E.g. AT&T? "How may I help you?"*
- *Non-task oriented*

System Initiative

- *Let's Go Bus Information*
  - *412 268 3526*
  - *Provides bus information for Pittsburgh*


- *Tell Me*
  - *Company getting others to build systems*
  - *Stocks, weather, entertainment*
  - *1 800 555 8355*

SDS Architecture



SDS Components

- *Interpretation*
  - *Parsing and Information Extraction*
  - *(Ignore politeness and find the departure stop)*
- *Generation*
  - *From SQL table output from DB*
  - *Generate “nice” text to say*

Siri-like Assistants

- *Advantages*
  - *Hard to type/select things on phone*
  - *Can use context (location, contacts, calendar)*
- *Target common tasks*
  - *Calling, sending messages, calendar*
  - *Fall back on google lookup*

SPDA: Scope

- *“Call John”*
- *“Call John, Bill and Mary and setup a meeting sometime next week about Plan B that’s fits my schedule”*
- *“Make a reservation at a local Chinese restaurant for 4 at 8pm.”*
- *“You should call your mom as its her birthday”*
- *“I have sent flowers to your mom as its her birthday”*

CALO (DARPA)

- *Cognitive Assistant that Learns Online*
  - *DARPA project (2003-2008)*
  - *Led by SRI (involved many sites, including CMU)*
- *Personal Assistant that Learns (Pal)*
  - *Answers questions*
  - *Learn from experience*
  - *Take initiative*
- *Spin-off company -> SIRI*
  - *Aquired by Apple in April 2010*

SPDA: Platform

- *Desktop*
  - *Computational power*
- *Phone (non-smartphone)*
  - *General Magic*
    - → *Was handheld, became phone based*
  - *Led into GM's OnStar*
- *Smartphone*
  - *Local to device*
  - *With Cloud*

Smartphone + Cloud

- *Smartphone*
  - *Know about user*
    - → *Contacts, Schedule etc*
    - → *Same speaker*
  - *Some computation possible on device*
- *Cloud*
  - *Learn from multiple examples*
  - *Retrain acoustic/language/understanding models*

Voice Search and User Feedback

- Voice Search
  - Google, Bing, Vlingo, Apple
- Get users to help label the data
  - Listen to user
  - Show best options
    - → They select which on is correct
- Find out how users actually speak
  - Full sentences vs “search terms”
  - How do English speakers say ethnic names

Voice Search: Simplifications

- *Too many words …*
- *Context*
  - *Where you are (location: home/not home)*
  - *What is on your phone (contacts)*
  - *What you've said before*

Personality

- *Have a character*
  - *Calls you by name (you choose)*
  - *Pushy, helpful, nagging …*
  - *Allow user choice*
- *Personalize it*
  - *May form better relationship with it*
- *e.g. Siri*
  - *US and UK are female/male*

Make it do things well

- *Targeted apps*
  - *Chose what it will do well*
- *Say, 12 different apps*
  - *Have target (hand written) interaction*
  - *Chose what fields you need, and how to intereact with the back end data*
  - *If all else fails dump result in Google*
- *Hardware aid*
  - *Infra-red detector for VAD*

Marketing

- *Make sure people know its there*
  - *(Voice search has been on PDA's for years)*
  - *Get a *lot* of people to use it*
  - *Give "silly" examples*
    - → *People will repeat them, you can adapt your system and expect them to say them*

Know Your Users

- *Young educated*
- *Standard English speakers*
  - *(Non-native too?)*
- *Can you train them to use it better*
  - *Get them to adapt*

Will it work?

- *Will people talk in public*
  - *Talking on the phone is now acceptable*
  - *Talking to the phone …*
- *Will people continue to use it*
  - *Cool at first, but easier to use menus*
  - *Only use for setting alarms*
- *Long term use …*
- *But others may join in anyway*

Speech and NLP

- *Same statistical methods*
  - *Bayes, n-gram, classification trees*
- *NLP in speech*
  - *POS tagging (in new languages)*
  - *Parsing (Syntactic and Prosodic)*
  - *Information extraction*
  - *Dialog/Discourse analysis*
  - *“ASR output” as “noisy” text*

Novel Speech and Language

- *Generating Poetry*
  - *Healthcare messages for non-literate*
  - *Appropriate rhyming and cultural references*
- *Emotion ID*
  - *Is this person angry when they are calling us*
- *Singing*



11-492 Speech Processing

- *Fall Class*
- *Covers*
  - *Speech Recognition, Synthesis, Dialog systems*
  - *Speech ID, evaluation*
  - *Building real systems (ASR, TTS, SDS)*

LT Minor

- *Language Technologies Minor*
  - *11-721 Grammars and Lexicons*
  - *Plus 3 electives e.g.*
    - → *11-411 Natural Language Processing*
    - → *15-492 Speech Processing*
    - → *11-441 Search Engines and Web Mining*
    - → *Or other LT (Masters) course*
  - *Plus project*
    - → *Often leading to a publication*