Speech synthesis

Speech synthesis

- What is the task?
  - Generating natural sounding speech on the fly, usually from text
- What are the main difficulties?
  - What to say and how to say it
- How is it approached?
  - Two main approaches, both with pros and cons
- How good is it?
  - Excellent, almost unnoticeable at its best
- How much better could it be?
  - marginally

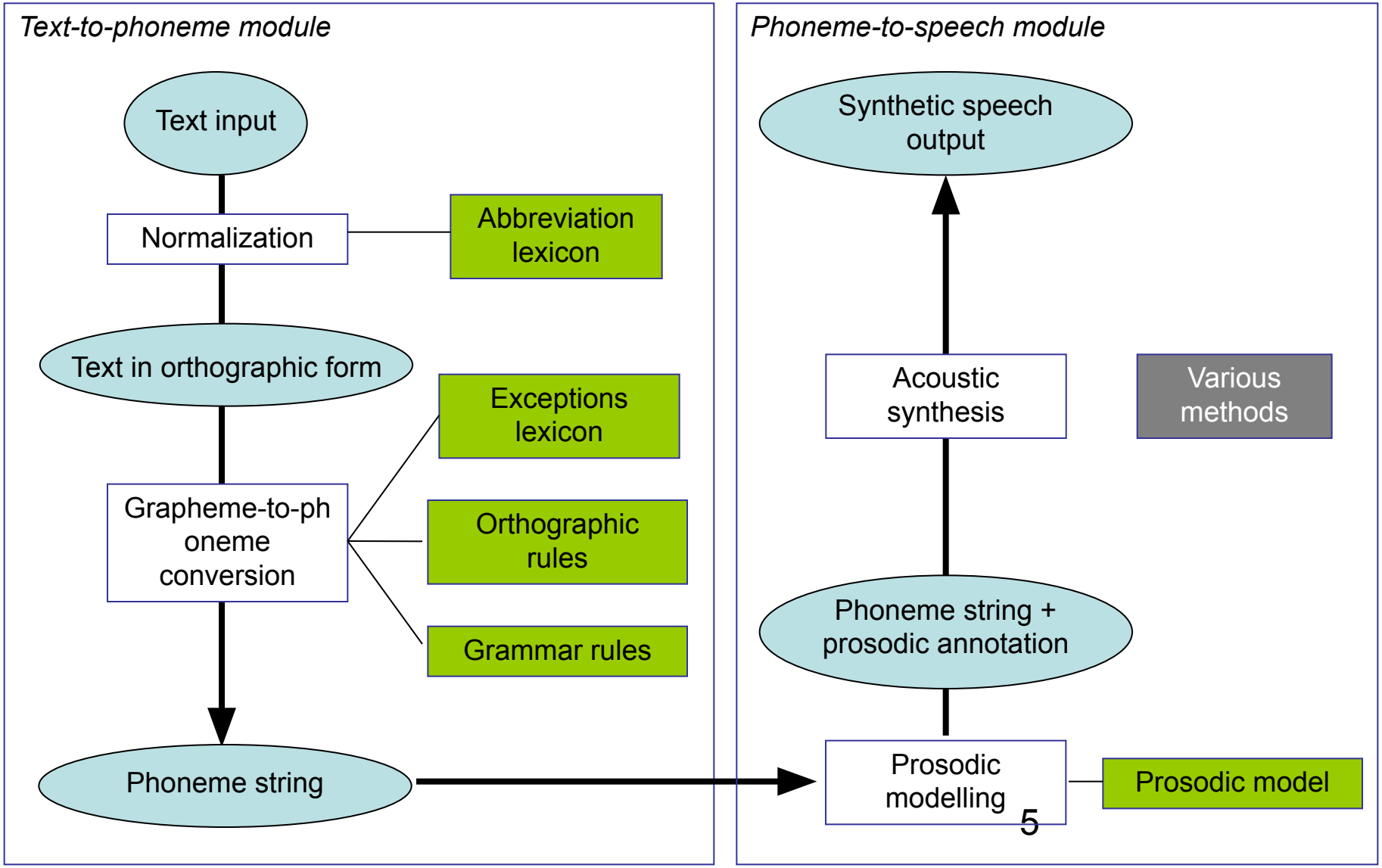
Input type

- Concept-to-speech vs text-to-speech
- In CTS, content of message is determined from internal representation, not by reading out text
  - E.g. database query system
  - No problem of text interpretation

Text-to-speech

- What to say: text-to-phoneme conversion is not straightforward
  - *Dr Smith lives on Marine Dr in Chicago IL. He got his PhD from MIT. He earns $70,000 p.a.*
  - *Have toy read that book? No I'm still reading it. I live in Reading.*
- How to say it: not just choice of phonemes, but allophones, coarticulation effects, as well as prosodic features (pitch, loudness, length)

Architecture of TTS systems



Text normalization

- Any text that has a special pronunciation should be stored in a lexicon
  - Abbreviations (Mr, Dr, Rd, St, Middx)
  - Acronyms (UN but UNESCO)
  - Special symbols (&, %)
  - Particular conventions (£5, $5 million, 12°C)
  - Numbers are especially difficult
    - 1995 2001 1,995 □236 3017 233 4488

Grapheme-to-phoneme conversion

- English spelling is complex but largely regular, other languages more (or less) so
- Gross exceptions must be in lexicon
- Lexicon or rules?
  - If look-up is quick, may as well store them
  - But you need rules anyway for unknown words
- MANY words have multiple pronunciations
  - Free variation (eg *controversy*, *either*)
  - Conditioned variation (eg *record*, *import*, weak forms)
  - Genuine homographs

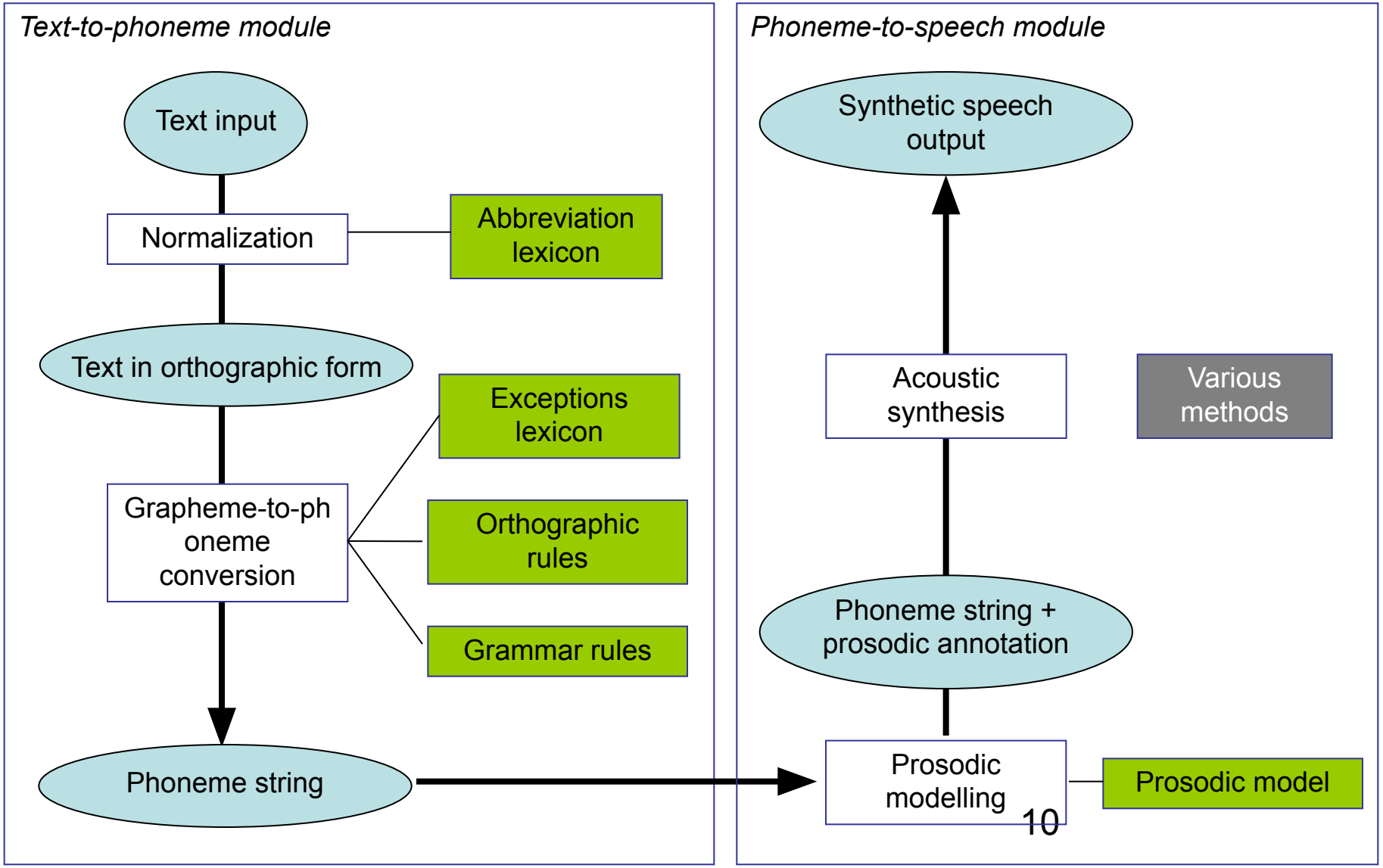
Grapheme-to-phoneme conversion

- Much easier for some languages (Spanish, Italian, Welsh, Czech, Korean)
- Much harder for others (English, French)
- Especially if writing system is only partially alphabetic (Arabic, Urdu)
- Or not alphabetic at all (Chinese, Japanese)

Syntactic (etc.) analysis

- Homograph disambiguation requires syntactic analysis
  - *He makes a record of everything they record.*
  - *I read a lot. What have you read recently?*
- Analysis also essential to determine appropriate prosodic features

Architecture of TTS systems



Prosody modelling

- Pitch, length, loudness
- Intonation (pitch)
  - essential to avoid monotonous robot-like voice
  - linked to basic syntax (eg statement vs question), but also to thematization (stress)
  - Pitch range is a sensitive issue
- Rhythm (length)
  - Has to do with pace (natural tendency to slow down at end of utterance)
  - Also need to pause at appropriate place
  - Linked (with pitch and loudness) to stress

Acoustic synthesis

- Alternative methods:
  - Articulatory synthesis
  - Formant synthesis
  - Concatenative synthesis
  - Unit selection synthesis

Articulatory synthesis

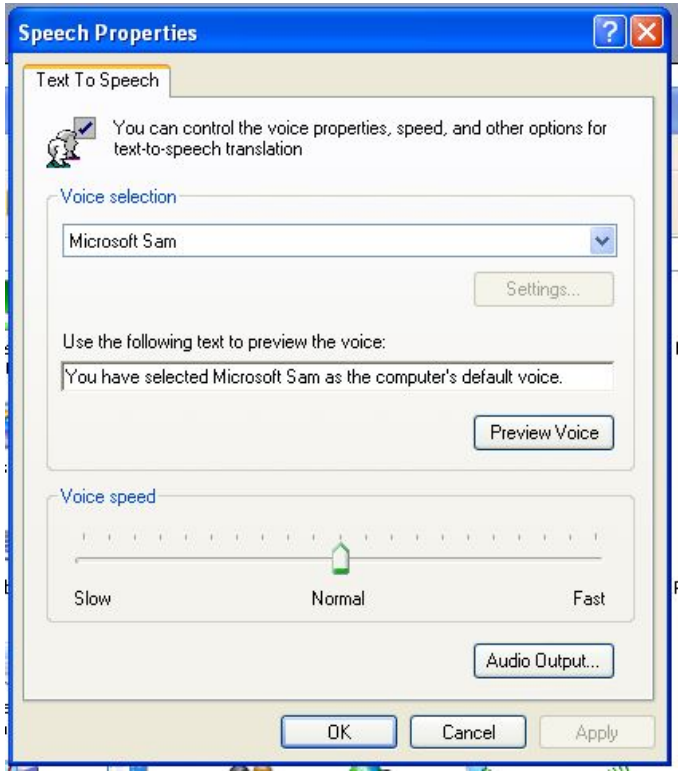
- Simulation of physical processes of human articulation
- Wolfgang von Kempelen (1734-1804) and others used bellows, reeds and tubes to construct mechanical speaking machines
- Modern versions simulate electronically the effect of articulator positions, vocal tract shape, etc.
- Too much like hard work

Formant synthesis

- Reproduce the relevant characteristics of the acoustic signal
- In particular, amplitude and frequency of formants
- But also other resonances and noise, eg for nasals, laterals, fricatives etc.
- Values of acoustic parameters are derived by rule from phonetic transcription
- Result is intelligible, but too “pure” and sounds synthetic

Formant synthesis

- Demo:
  - In control panel select “Speech” icon
  - Type in your text and Preview voice
  - You may have a choice of voices

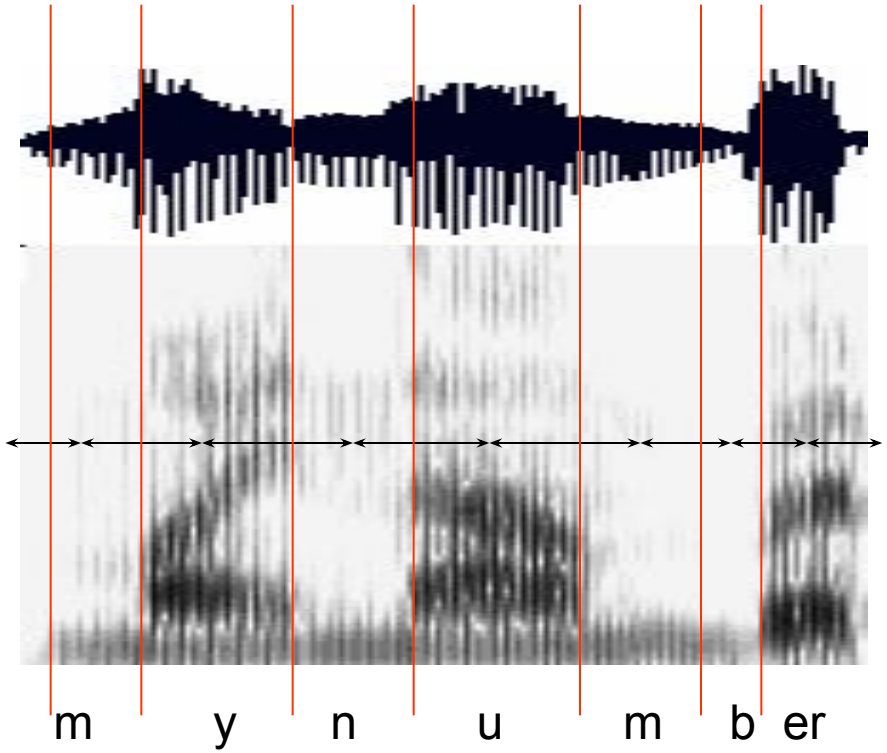


Concatenative synthesis

- Concatenate segments of pre-recorded natural human speech
- Requires database of previously recorded human speech covering all the possible segments to be synthesised
- Segment might be phoneme, syllable, word, phrase, or any combination
- Or, something else more clever ...

Diphone synthesis

- Most important for natural sounding speech is to get the transitions right (allophonic variation, coarticulation effects)
- These are found at the boundary between phoneme segments
- “diphones” are fragments of speech signal cutting across phoneme boundaries
- If a language has P phones, then number of diphones is ~P^2 (some combinations impossible) – eg 800 for Spanish, 1200 for French, 2500 for German)



Diphone synthesis

- Most systems use diphones because they are
  - Manageable in number
  - Can be automatically extracted from recordings of human speech
  - Capture most inter-allophonic variants
- But they do not capture all coarticulatory effects, so some systems include triphones, as well as fixed phrases and other larger units (= USS)

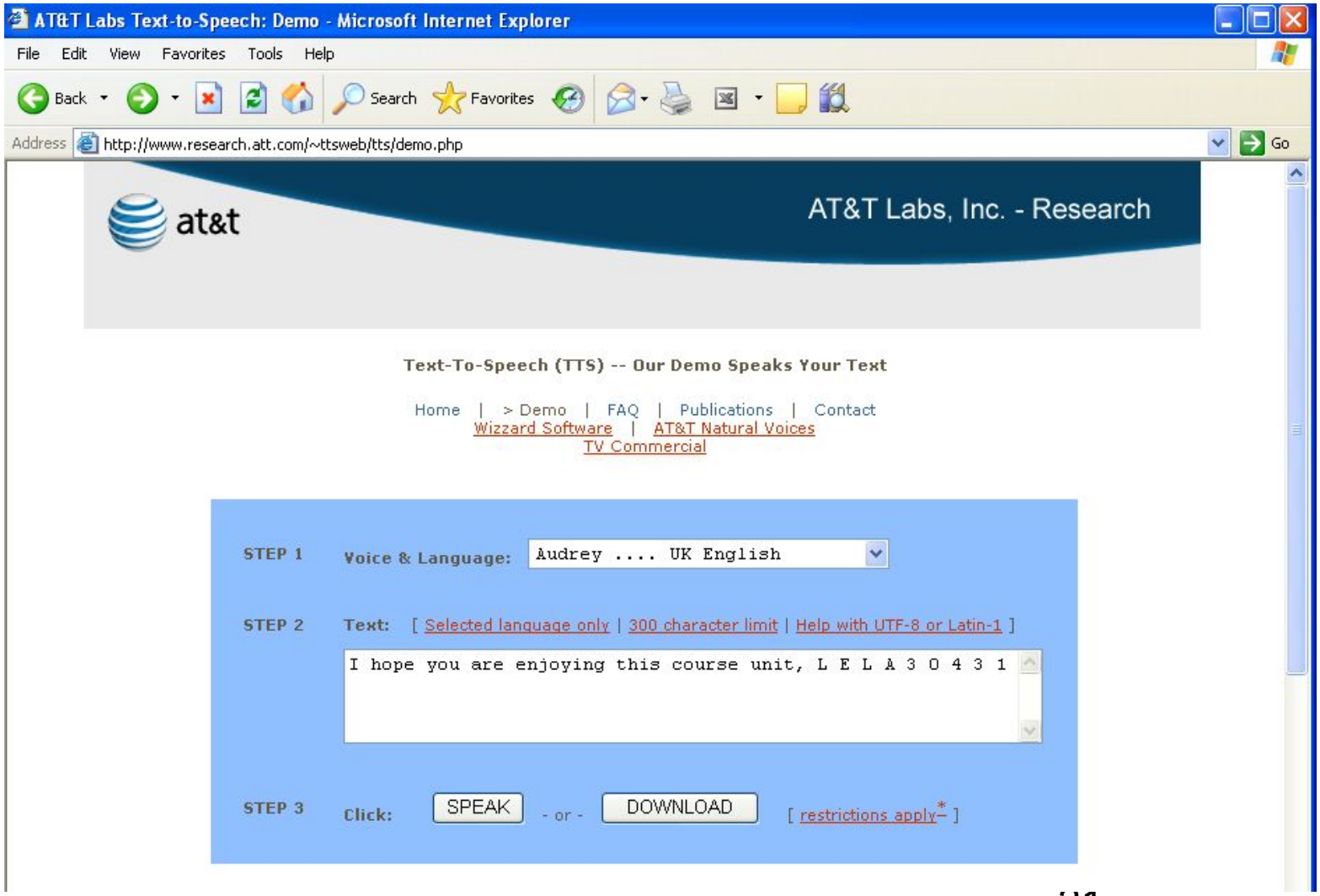
Concatenative synthesis

- Input is phonemic representation + prosodic features
- Diphone segments can be digitally manipulated for length, pitch and loudness
- Segment boundaries need to be smoothed to avoid distortion

Unit selection synthesis (USS)

- Same idea as concatenative synthesis, but database contains bigger variety of “units”
- Multiple examples of phonemes (under different prosodic conditions) are recorded
- Selection of appropriate unit therefore becomes more complex, as there are in the database competing candidates for selection

Speech synthesis demo



Speech synthesis demo