Module 3

Text processing

Roadmap

- Modules 1-2: The basics
- Modules 3-5: Speech synthesis
- Modules 6-9: Speech recognition

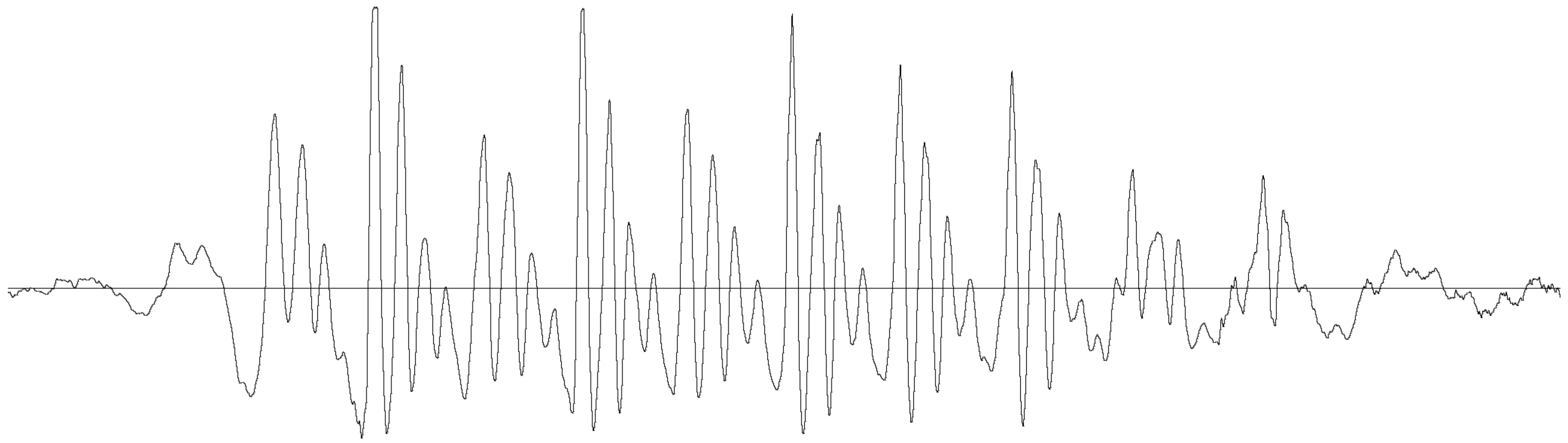
- Block 1 Week 4
  - Module 3: text processing
- Block 1 Week 5
  - Class trip
  - Module 4: pronunciation & prosody
- Block 1 Week 6
  - Assignment Q&A
  - Module 5: waveform generation
- Block 1 Week 7
  - Submission of first assignment

Orientation

- Speech
  - a continuous 1-dimensional signal
  - phonemes (categories of speech sounds)

- Text
  - messy stuff !
  - needs "tidying up" (normalisation)

- Predicting speech from text
  - via an intermediate representation



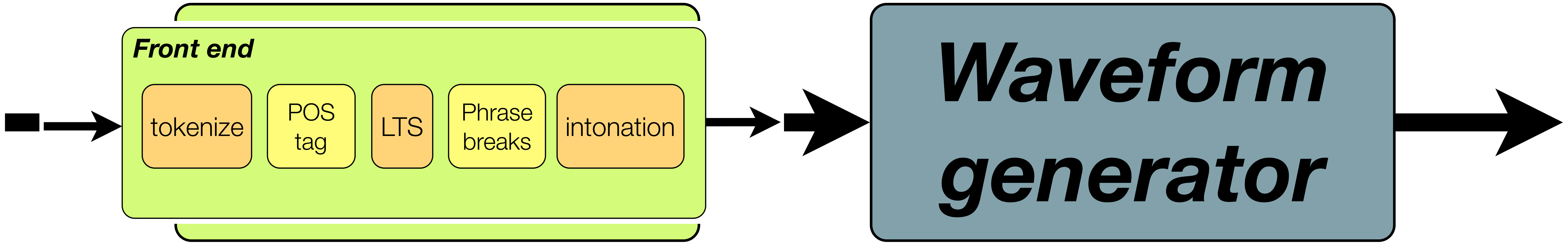
THE INTERNATIONAL PHONETIC ALPHABET (revised to 2015)

CONSONANTS (PULMONIC)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap		ⱱ		ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

What you should already know

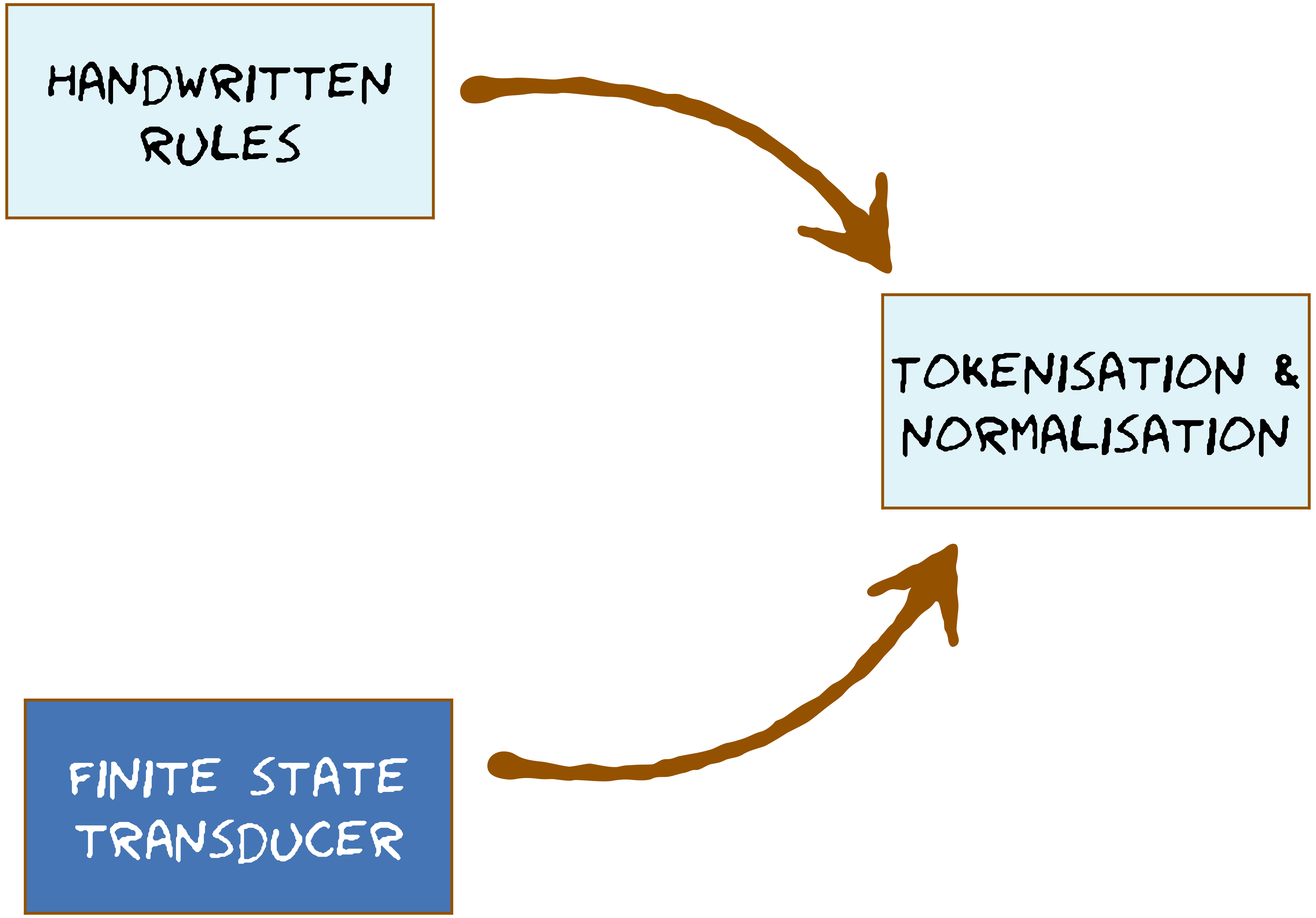
- From the videos & readings
  - text-to-speech pipeline
  - dealing with Non-Standard Words (NSWs)



Today's topics - Module 3: text processing

	THEORY					APPLICATION					
	SPEECH			SIGNAL PROCESSING	PROBABILISTIC MODELLING	SPEECH SYNTHESIS		AUTOMATIC SPEECH RECOGNITION			
	SIGNALS	PRODUCTION	PERCEPTION			FRONT END	WAVEFORM GENERATION	FEATURE EXTRACTION	PATTERN MATCHING	HIDDEN MARKOV MODELS	CONNECTED SPEECH
CONCEPTS	TIME DOMAIN	SOUND SOURCE	PITCH	DIGITAL SIGNAL	DESCRIBING DATA	TOKENISATION & NORMALISATION	WAVEFORM CONCATENATION	SERIES EXPANSION	EXEMPLAR	GENERATIVE MODEL OF SEQUENCES	HIERARCHY
	PERIODIC SIGNAL	HARMONICS	COCHLEA	SHORT-TERM ANALYSIS	DISCRETE & CONTINUOUS VARIABLES	PRONUNCIATION	DIPHONE	FEATURES	DISTANCE		SUB-WORD UNIT
	FREQUENCY DOMAIN	VOCAL TRACT RESONANCE & FORMANTS	MEL SCALE	SPECTRAL ENVELOPE	JOINT, CONDITIONAL, BAYES' FORMULA	PROSODY		FEATURE ENGINEERING	SEQUENCE	HIDDEN STATE SEQUENCE	N-GRAMS
MODELS & DATA STRUCTURES	FILTER	RESONANT TUBE	FILTERBANK	IMPULSE TRAIN	GAUSSIAN	FINITE STATE TRANSDUCER		FEATURE VECTOR	SEQUENCE OF FEATURE VECTORS	HIDDEN MARKOV MODEL	
	IMPULSE RESPONSE	SOURCE-FILTER MODEL	PHONEME	PITCH PERIOD	GENERATIVE MODEL	DECISION TREE			GRID	LATTICE	GRAPH
ALGORITHMS & ANALYSIS				FOURIER ANALYSIS	FITTING A GAUSSIAN TO DATA	HANDWRITTEN RULES	OVERLAP-ADD	MFCCS	DYNAMIC PROGRAMMING (DTW)	DYNAMIC PROGRAMMING (VITERBI)	COMPOSITION ("COMPILING")
				CEPSTRAL ANALYSIS	CLASSIFICATION	LEARNING DECISION TREES	TD-PSOLA			BAUM WELCH	APPROXIMATION (PRUNING)

Today's topics - Module 3: text processing



Speech synthesis - text processing

- Representing linguistic information using data structures
- Designing features for classifying Non-Standard Words (NSWs) into categories
- Writing algorithms to expand NSWs

How to represent linguistic information?

- The Heterogeneous Relation Graph (HRG) formalism (as used in Festival)
- Basic data structure to represent a linguistic item: **feature structure**
  - an unordered list of key-value pairs (*like a Python dictionary*)

$$word : \begin{bmatrix} \text{NAME} & abuse_1 \\ \text{POS} & noun \\ \text{TEXT} & abuse \\ \text{PRON} & /@buws/ \end{bmatrix}$$

Example taken from Taylor - Section 4.5

Nesting: values can themselves be feature structures

$$
phone: \begin{bmatrix} \text{NAME} & p \\ \text{STRESS} & 1 \\ \text{DISTINCTIVE FEATURES} & \begin{bmatrix} \text{VOICED} & false \\ \text{MANNER} & stop \\ \text{PLACE} & bilabial \end{bmatrix} \end{bmatrix}
$$

Example taken from Taylor - Section 4.5

How to represent linguistic information?

Data structures

- The Heterogeneous Relation Graph (HRG) formalism (as used in Festival)
- Basic data structure to represent a linguistic item: **feature structure**
    - an unordered list of key-value pairs (like a Python dictionary)
- **Relations** between linguistic items

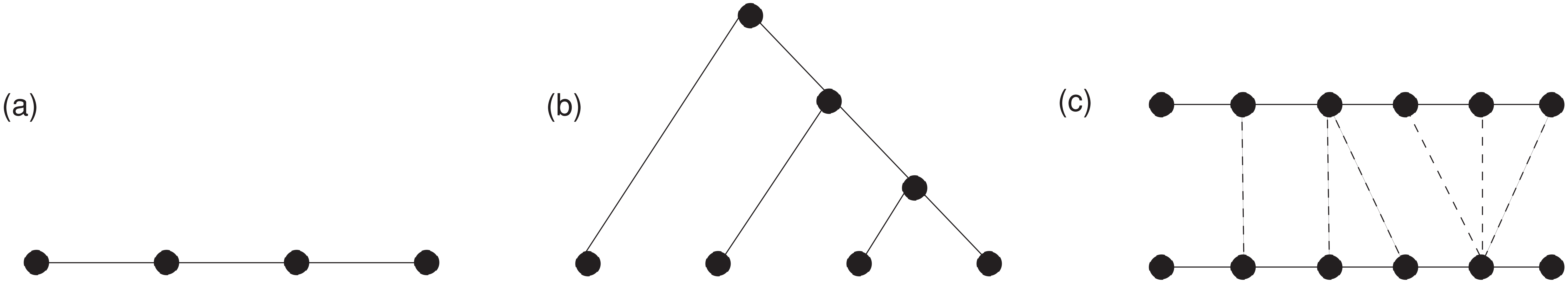


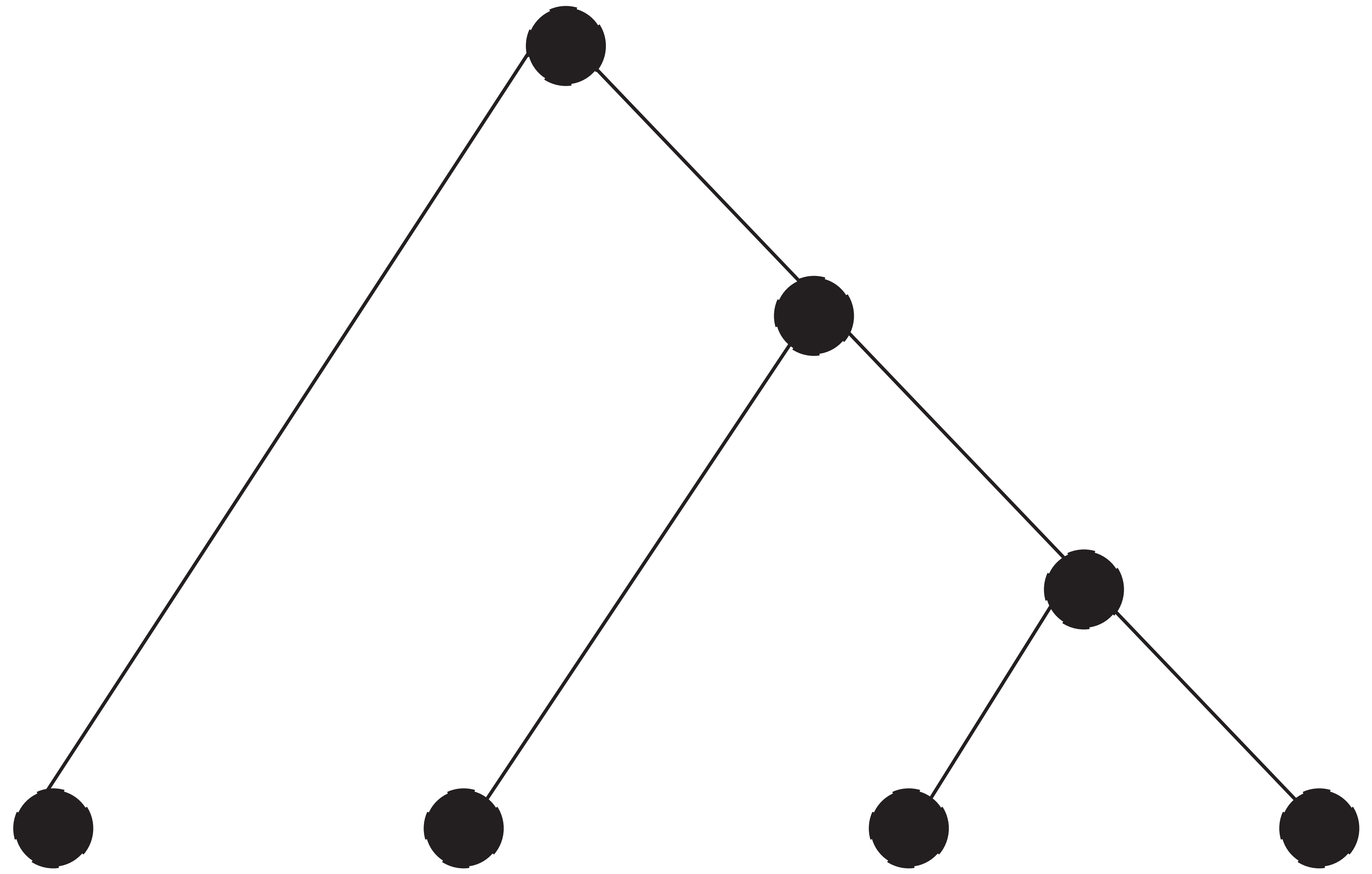
Figure 4.1 The three types of relation: (a) list relation, (b) tree relation and (c) ladder relation.

Taylor - Figure 4.1

List - for example, relation between the words in a sentence

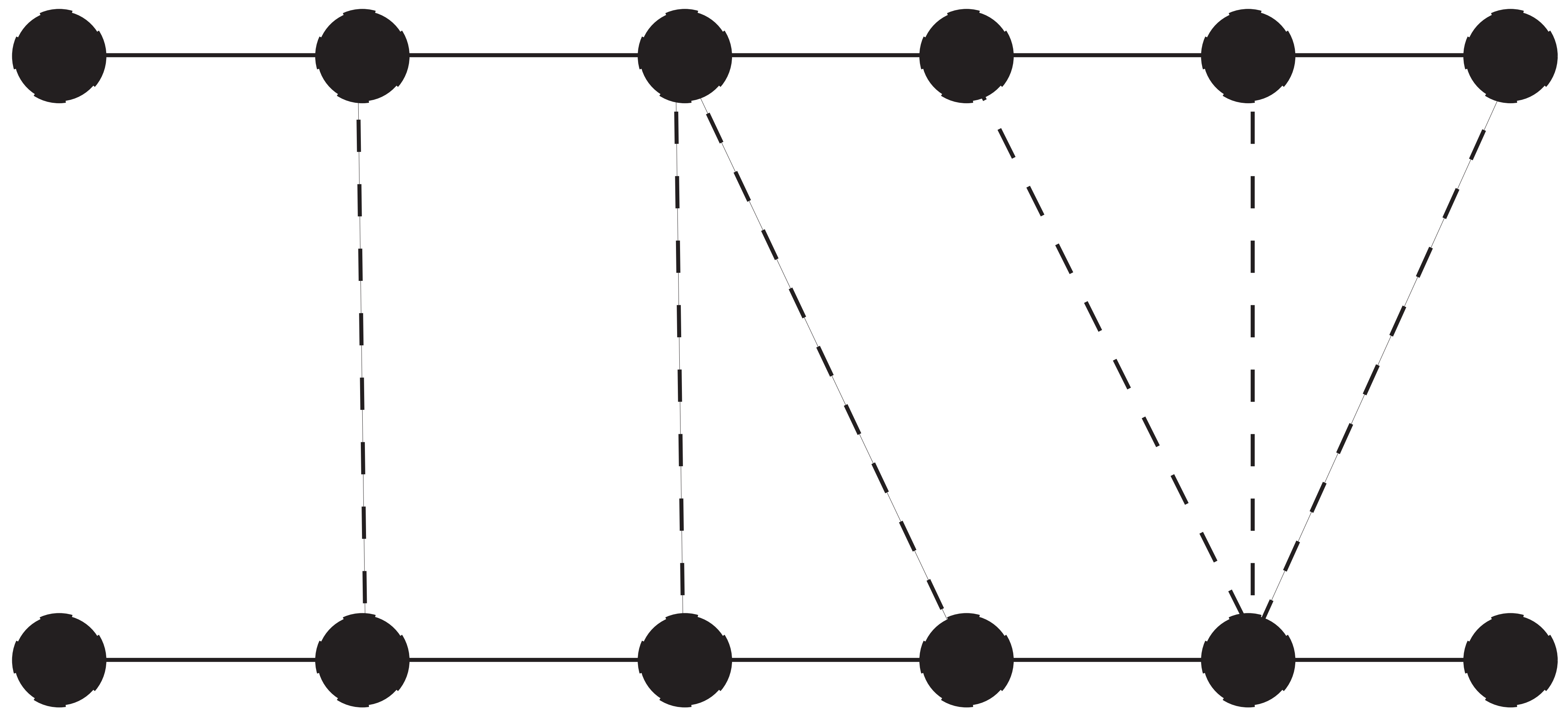
Taylor - Figure 4.1

Tree - for example, relation between words, syllables and phones



Taylor - Figure 4.1

Ladder - for example, relation between syllables and pitch accents



Taylor - Figure 4.1

Speech synthesis - text processing

- Representing linguistic information using data structures
- Designing features for classifying Non-Standard Words (NSWs) into categories
- Writing algorithms to expand NSWs

Design some features that might be useful for classifying NSWs

TABLE I. Taxonomy of non-standard words used in hand-tagging and in the text normalization models

	EXPN	abbreviation	adv, N.Y, mph, gov't
alpha	LSEQ	letter sequence	CIA, D.C, CDs
	ASWD	read as word	CAT, proper names
	MSPL	misspelling	geogaphy
	NUM	number (cardinal)	12, 45, 1/2, 0·6
	NORD	number (ordinal)	May 7, 3rd, Bill Gates III
	NTEL	telephone (or part of)	212 555-4523
	NDIG	number as digits	Room 101
N	NIDE	identifier	747, 386, I5, pc110, 3A
U	NADDR	number as street address	5000 Pennsylvania, 4523 Forbes
M	NZIP	zip code or PO Box	91020
B	NTIME	a (compound) time	3·20, 11:45
E	NDATE	a (compound) date	2/2/99, 14/03/87 (or US) 03/14/87
R	NYER	year(s)	1998, 80s, 1900s, 2003
S	MONEY	money (US or other)	$3·45, HK$300, Y20,000, $200K
	BMONEY	money tr/m/billions	$3·45 billion
	PRCT	percentage	75%, 3·4%
	SPLT	mixed or "split"	WS99, x220, 2-car
			(see also SLNT and PUNC examples)
	SLNT	not spoken,	word boundary or emphasis character:
M		word boundary	M.bath, KENT*RLTY, _really_
I	PUNC	not spoken,	non-standard punctuation: "***" in
S		phrase boundary	$99,9K***Whites, "…" in DECIDE…Year
C	FNSP	funny spelling	slloooooww, sh*t
	URL	url, pathname or email	http://apj.co.uk, /usr/local, phj@tpt.com
	NONE	should be ignored	ascii art, formatting junk

Table I from Sproat et al, "Normalization of non-standard words" Computer Speech and Language (2001) 15, 287–333
doi:10.1006/csla.2001.0169

Speech synthesis - text processing

- Representing linguistic information using data structures
- Designing features for classifying Non-Standard Words (NSWs) into categories
- Writing algorithms to expand NSWs

Write an algorithm to expand **`LSEQ`** (letter sequence) to words

- Your algorithm must handle these examples
  - IBM
  - DVD
  - UN
  - ABC

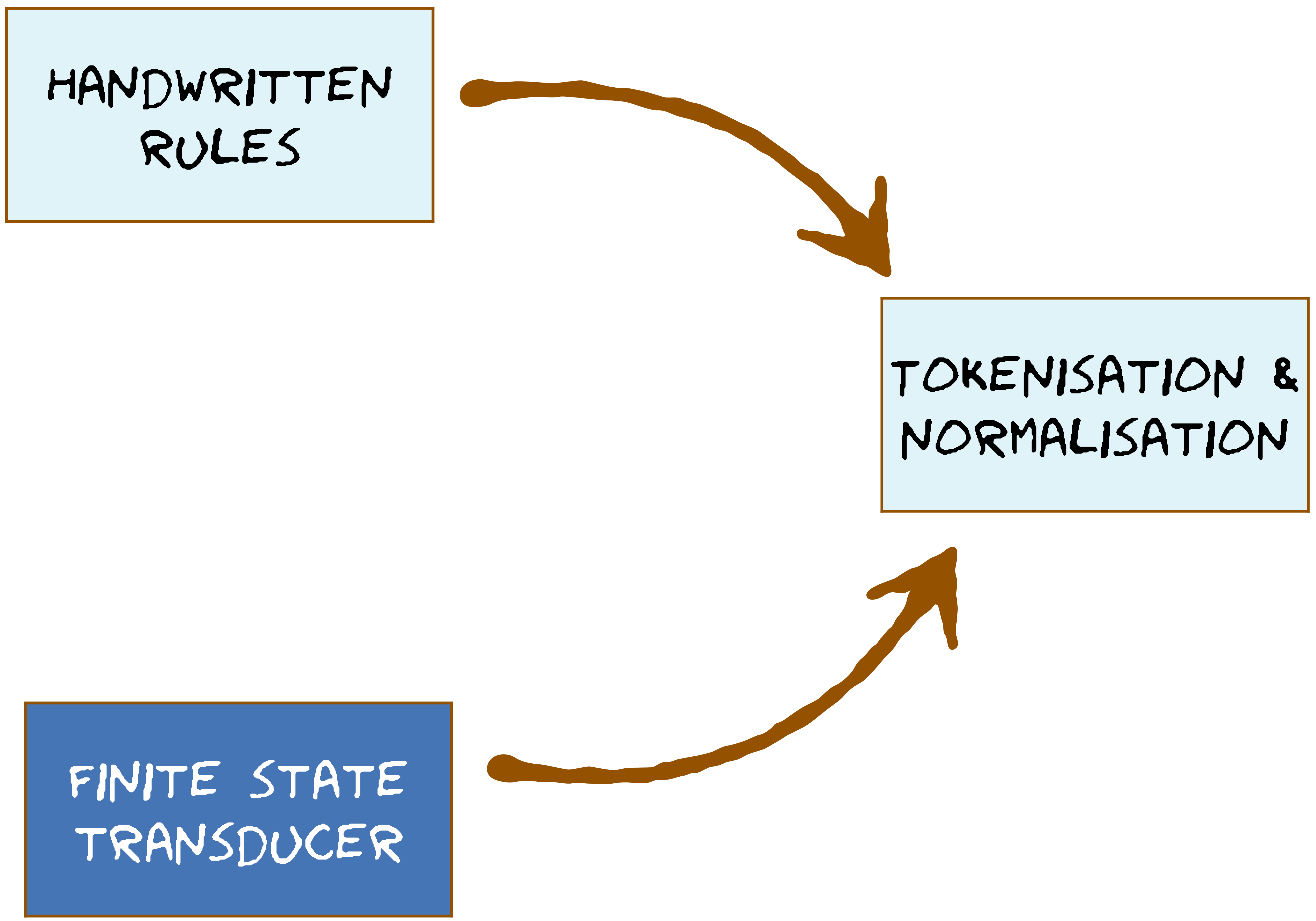
Write an algorithm to expand **`NUM`** (cardinal number) to words

- Your algorithm must handle these examples
  - 7
  - 21
  - -9
  - 3.1
  - 99.9

Write an algorithm to expand `PRCT` (percentage) to words

- Your algorithm must handle these examples
  - 50%
  - -30%
  - 4.5%

Today's topics - what we covered



What next?

- From the normalised text
  - predict **pronunciation**
  - product **prosody**

In Module 4

- That completes the **linguistic specification**

- From the linguistic specification
  - generate a **waveform**

In Module 5