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Text Normalization for Speech Systems for All Languages

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Text normalization

also known as standardization

Mapping non-standard words (symbols, numbers, abbreviations) to standard words (strings of characters that have a standard pronunciation).

Most text-to-speech systems are limited to standard words.

Original: It will cost $5 to buy 2lbs of apples

Normalized: It will cost five dollars to buy two pounds of apples

Text normalization of currency and measure. The colors in the original text correspond to the standard form in the normalized text.

Motivation

- Major degradations of perceived quality in Text To Speech systems can be traced to problems involving text normalization
- Previous work attempted the automatic mapping of non-standard words to standard words using statistical, neural, and rule-driven approaches, which work but **have poor generalizability to new languages** or they **require experienced software developers** to implement

Related work: FST-based verbalizers

- Built through the **efficient sourcing of language-specific data collected through questionnaires** given to native speakers of a language
- The **collected data contains all the necessary information to bootstrap the number grammar induction system** to parameterize a verbalizer template, which will then be used by formal language experts to develop FST-based text normalization systems

Our method takes in the idea of text normalization as a **data collection problem** and improves it further by providing a **user-friendly interface** and a feature which allows users (both the native speaker source and the formal language expert) to **easily amend the provided information** and the text normalization system for any obvious mistakes.

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S. Ritchie, R. Sproat, K. Gorman, D. van Esch, C. Schallhart, N. Bampounis, B. Brard, J. F. Mortensen, M. Holt, and E. Mahon, “Unified verbalization for speech recognition & synthesis across languages.” in INTERSPEECH, 2019, pp. 3530–3534.

Given access to a native speaker, what are the most important questions we should ask them in order to perform *basic counting* in their language, without having to write additional code?

Semiotic classes

Groups of non-standard words that occur in text. Semiotic classes are **distinguishable by the patterns** within the non-standard words.

Semiotic class	Examples
Cardinal	1235523, 1,000,000
Time	19:10, 1:00PM
Decimal	21.25, 0.034
Digit	15213, 007
Measure	90%, 5lbs
Money	$23, 50.00USD

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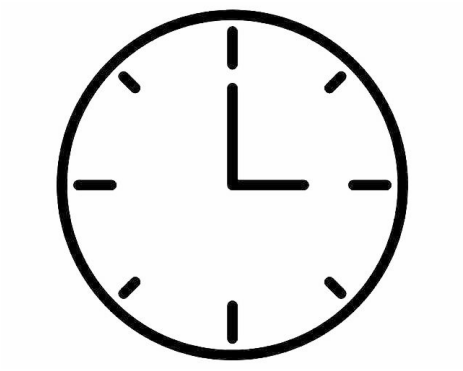
Taylor, Paul. Text-to-speech synthesis. Cambridge university press, 2009.

Challenges

Standardization **within a semiotic class.**



"The time is now, twelve fifteen **AM**."

"It is now a **quarter** past midnight."

"Currently, it is fifteen **minutes** past twelve."

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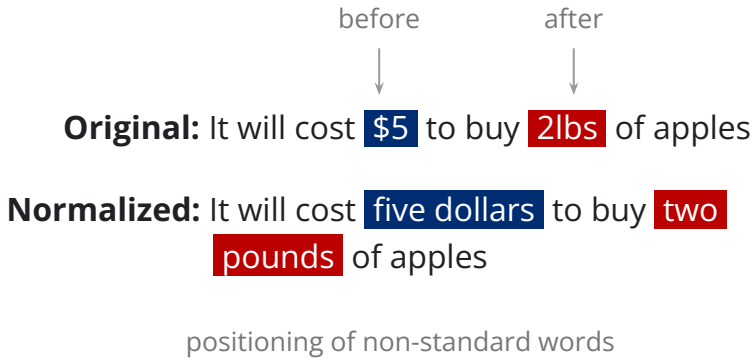
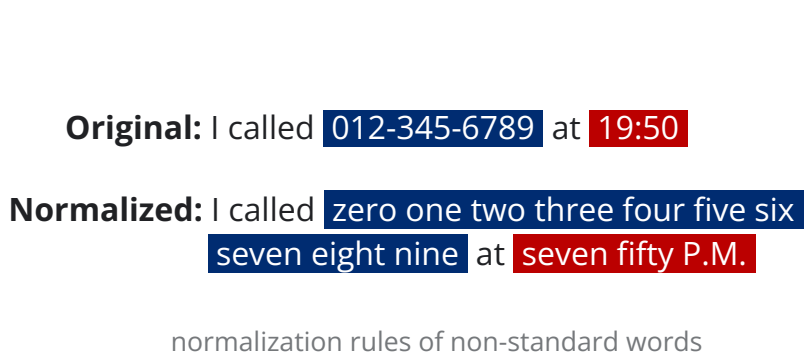
Challenges

Standardization across **various semiotic classes.**





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Challenges

Standardization across **various languages** within the **same semiotic class**.

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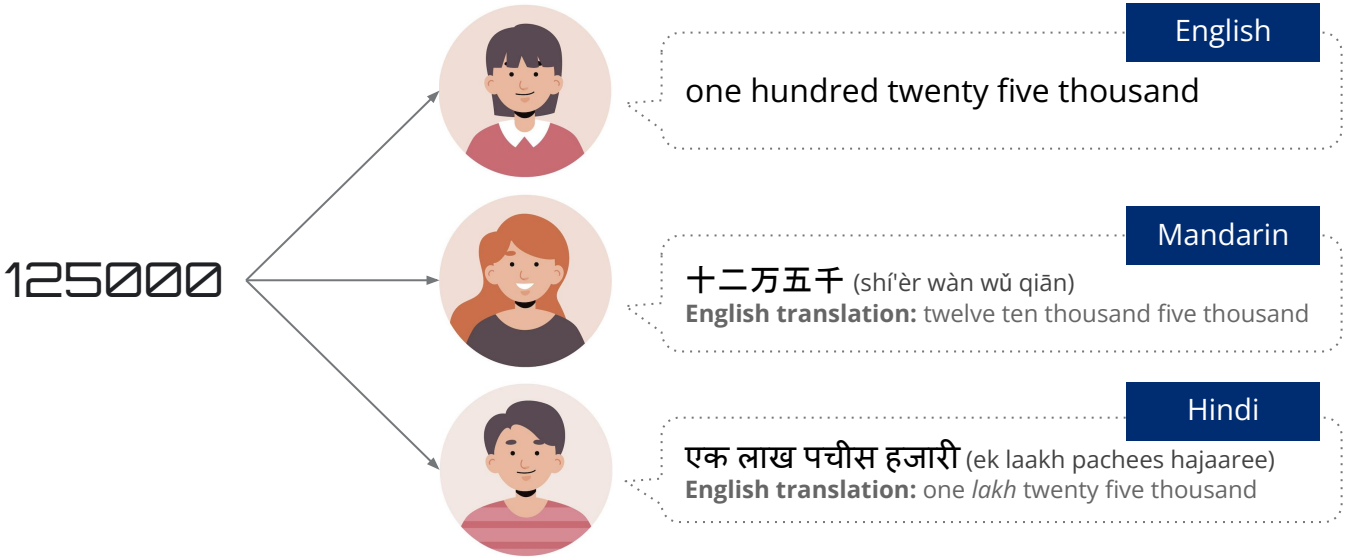

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Proposal

- A method to **collect data** regarding the counting system, digit mapping, and relevant information with respect to the different semiotic classes from **native speakers of a language (without any coding experience)** to allow for the development of a **generalizable** text normalization system

Research questions

- **RQ1:** Which non-standard words appear in text?
- **RQ2:** How do we ask questions to get our answers?
- **RQ3:** How do we make it easy to answer such questions?
- **RQ4:** How do we address variability?
- **RQ5:** How do we extend this to a full front end?

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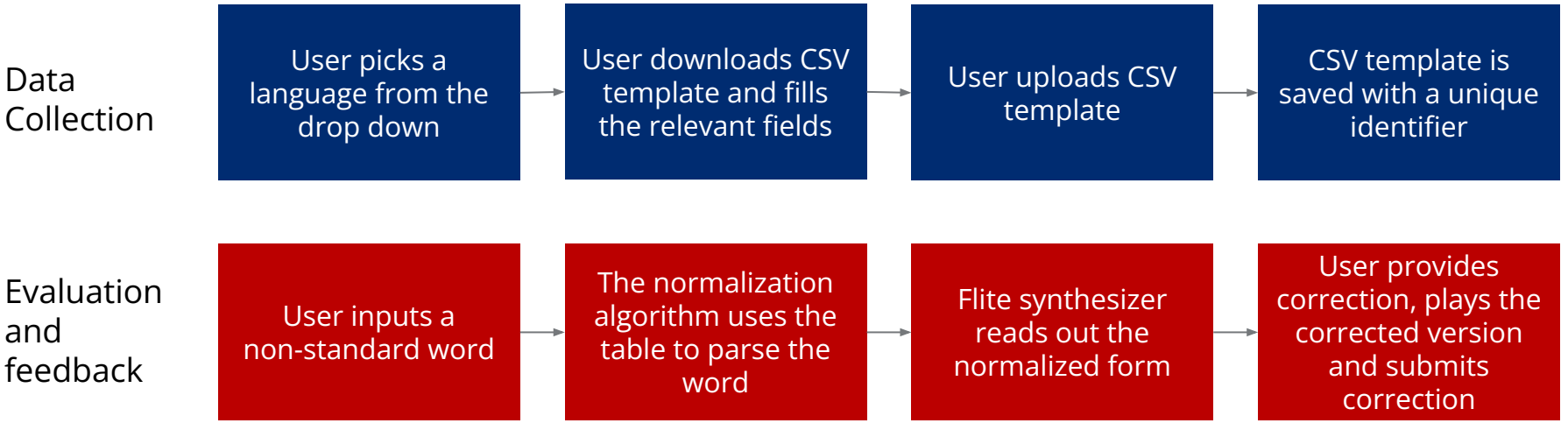
Methodology



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Methodology: Data Collection

Main goal: obtain sufficient information from a native speaker in order to map non-standard numerical text to its standardized form, ideally by asking the minimum number of questions

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Methodology: Data Collection

- We decided that it is sufficient to collect information on the **digits 1-100**, as well as the **numbers denoting the tens position**, such as hundred, thousand, up to a billion
- We have requested some information from the user regarding the **additional symbols** that might exist in numerical text which are **telling of the different semiotic classes**, such as the decimal point (.), currency symbol and its normalized form ($ -> dollar), percentage sign (%), and more

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Methodology: Data Collection

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Methodology: Text Normalization Algorithm

- When the user uploads the CSV file containing information on the non-standard to standard text mapping for a particular language, the back-end will **parse the information into a hashmap to be normalized using a Python script**
  - At the moment, the algorithm is able to normalize text in the form of whole numbers, phone numbers, currency, floating-point numbers, time, and percentages
- The algorithm takes into account how the numbers are **chunked** and **processes each chunk accordingly**
  - e.g. `process("123456") -> process("123") + process("456")`
- The algorithm will also **take into account the surrounding symbols** to identify the semiotic class by querying for specific symbols such as decimal points, colons, and more
  - e.g. `if currency_symbol in text: process_currency(text)`

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Methodology: Text Normalization Algorithm

- For **currencies**, **floating-point numbers** and **percentages**, the non-standard text will be **split depending on their position with respect to the decimal point**
  - The numbers before the decimal point will be read as a whole number, while the numbers after the decimal point will be read out individually.

    e.g. `process_currency($2.52) -> process(2.52) + process($) -> process(2) + process(52) + process($) -> two point five two dollars`

  - **Future work:** take into account stylistic preferences, e.g. two point five two dollars vs. two dollars and fifty two cents

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Methodology: Text Normalization Algorithm

- **Phone numbers** will be normalized into **individual numbers**, similar to the numbers behind a decimal point
  - e.g. `process(4122682000) -> process(4) + process(1) + … + process(0)`
  - **Problems:** stylistic preference varies across countries, e.g. placement of parentheses in US phone numbers to denote area code ((412) 268-2000), length of hotlines are usually short (911), so would need context clues
- Texts belonging to the **time** semiotic class are usually indicated by a colon in the middle of a string of digits (20:53), reading out the numbers before the colon, followed by a space, and then the numbers after the colon
  - e.g. `process(20:53) -> process(20) + pause + process(53)`
  - **Problems:** stylistic choices of using AM/PM if 12-hour time is preferred

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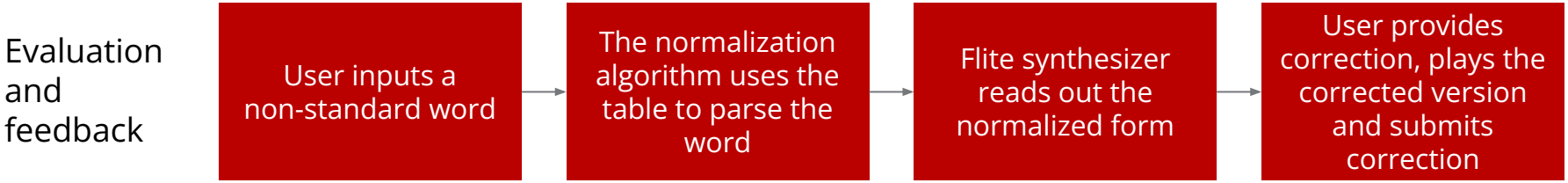
Methodology: Evaluation and Feedback

- We **provide a feedback collection system** where a user will be able to **correct an erroneous normalization** after the .wav file is generated and played on the website
- After the user has input the correct normalization, they will **be able to listen to the amended normalization** (generated by a Flite synthesizer) and they will be able to submit it once they are satisfied



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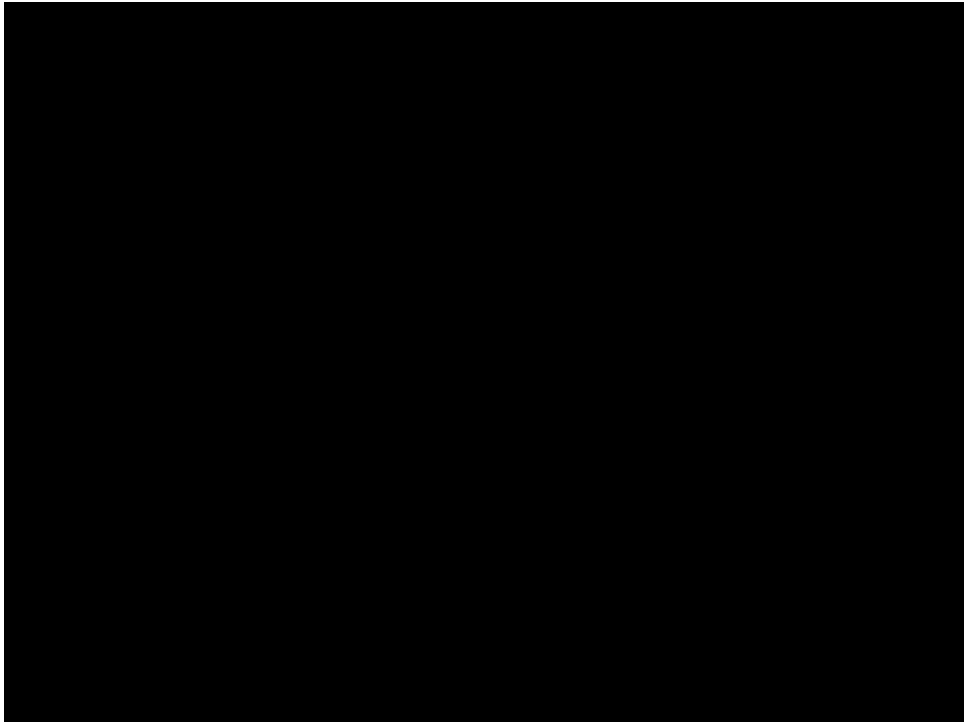
Methodology: Evaluation and Feedback



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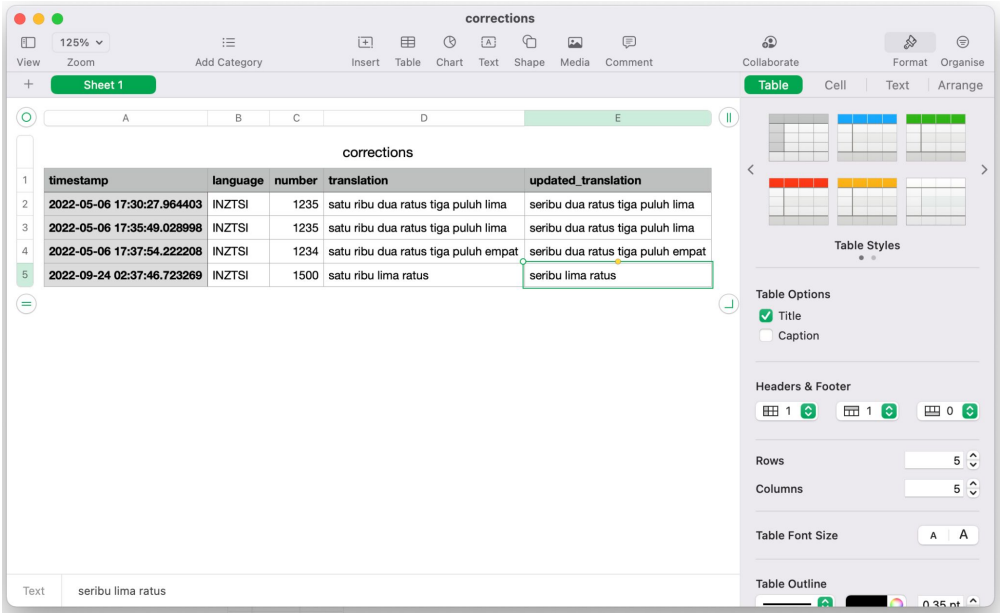
Methodology: Qualitative Evaluation

Observation

For the Indonesian language, we can see that the errors have one thing in common: even though “1” is “satu” and thousand is “ribu”, the verbalization of 1000 is not “satu ribu” but “seribu”.



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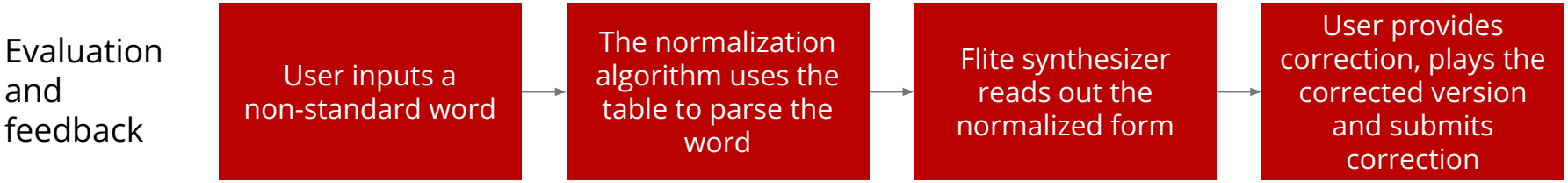
Methodology: Evaluation and Feedback

- Given enough users and feedback from erroneous normalizations, this data will allow us to **identify common mistakes** that arise from the text normalization of specific languages and **make the appropriate amendments to the algorithm** or **add new fields to collect more information on the CSV file**



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Results

RQ1: Which non-standard words appear in text?

We have found that the type of non-standard words which involve numerical characters can be grouped into different semiotic classes. The presence of a semiotic class highly depends on the corpus the text originates from.

RQ2: How do we ask questions to get our answers?

We collect information from a native speaker through a CSV file that would be uploaded to the web app. The table will contain information such as the digit normalization from 1-100, common symbols such as currency and percentage, decimal point, number chunking and more.

RQ3: How do we make it easy to answer such questions?

We present an accompanying web-app to our tool which was designed with intuitiveness in mind. Through the website, a native speaker with no prior programming skills will be able to input the non-standard to standard mapping of various words. The back-end of the website will then automatically parse the spreadsheet, allowing the user to read and listen to the normalization of the non-standard text and provide any feedback or corrections.

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Results

RQ4: How do we address variability?

We store multiple tables from various languages and we will take the most common mapping for each item. This will also solve the issue of dialectal variation that may arise from the variety of input collected from the native speakers.

RQ5: How do we extend this to a full front-end?

There are still plenty of non-standard text that may appear in a corpus which do not include numerical values (e.g. shortened form/abbreviations which are commonly used (e.g. dept → department)). We would like to extend our method to be able to capture these nuances from multiple languages using the same data collection process.