



A computational model for speech disorders using problematic phonemes with ontological reasoning

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Abstract

This work presents the development of an ontology in the domain of speech disorders, in order to become a computational model to support therapists for diagnosis and possible treatment. Speech disorders, phonemes and some additional information are classified using taxonomies obtained from speech disorders specialized literature. The development of the model is based on Natural Language Processing (NLP) and Information Retrieval (IR) techniques. A classification based in problematic phonemes is suggested as a complement to the diagnostic tool in the model.

Introduction

- A speech or language disorder refers to problems of communication.
- The importance of an early detection and diagnosis lies in the fact that the prognosis of the treatment depends on the cause of the disorder and in an opportune treatment.
- One of the first clues to detect a speech disorder is the mispronunciation of characteristic phonemes, those phonemes could help to identify the existence of a speech disorder.
- An ontology is proposed to organize and search information such as different disorders, characteristics of each disorder, theory of therapy, taxonomy of speech disorders, problematic phonemes, as well as relations between all of them.

Ontology development

- **Formulate competency questions**, to define the domain and scope of the ontology, for instance:
 - Which problematic phoneme is related to a specific disorder?
 - Which disorder is related with the difficulty to pronounce the phoneme ‘r’?

- **Definition of classes**, identification of main concepts in the domain.

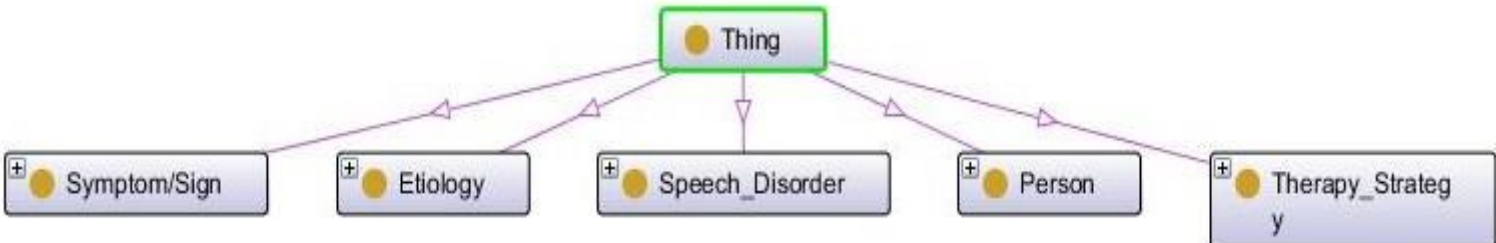


Figure 1. Main classes of the ontology.

- **Relations description**,

Table 1. Relations between classes.

Relation	Domain	Range	Inverse	Cardinality
Affects_to	Speech_Disorder	Patient	Suffers_a	N:1
Applies_a	Therapist	Therapy_Strategy	Is_applied_by	1:N
Gives_therapy_to	Therapist	Patient	Receives_therapy_from	1:N
Has_Cause	Speech_Disorder	Etiology	Is_cause_of	1:N

- **Consistency test**, Protégé’s logical reasoner is used with the probe class technique.

- **Describe primitive and defined classes**, a class that has at least one set of necessary and sufficient conditions is known as a *defined class*.
- **Proposing an additional classification**, in addition to the main classes defined in the ontology, is proposed a new class that is a set of characteristic problematic phonemes for each speech disorder. Also another new class was added: *Additional_Characteristic*; it includes useful information for a better classification of the suspected speech disorder.

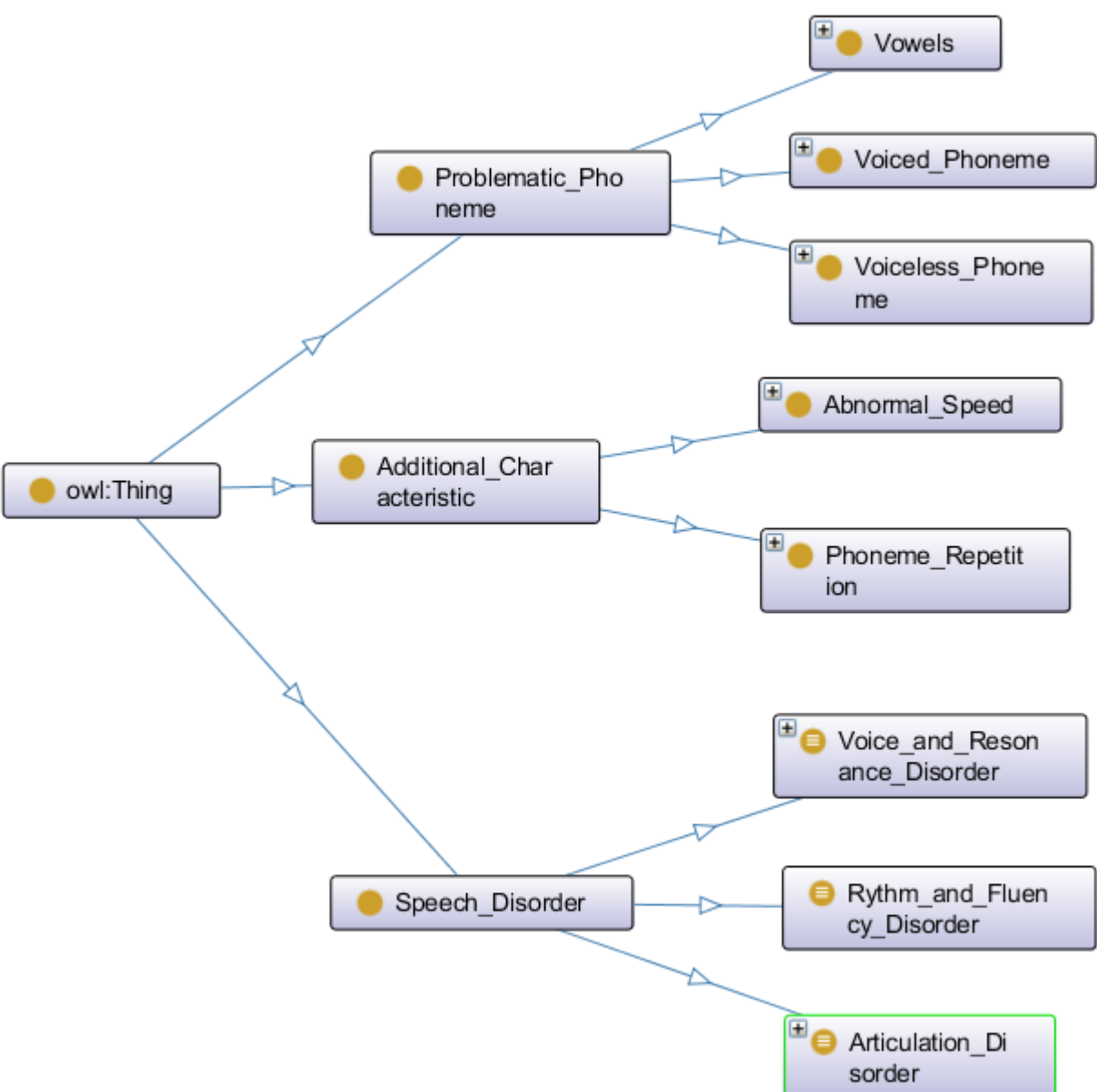


Figure 2. Graph representing the taxonomy for the proposed classification.

- With the inclusion of these new classes there are also new non-taxonomic relations.

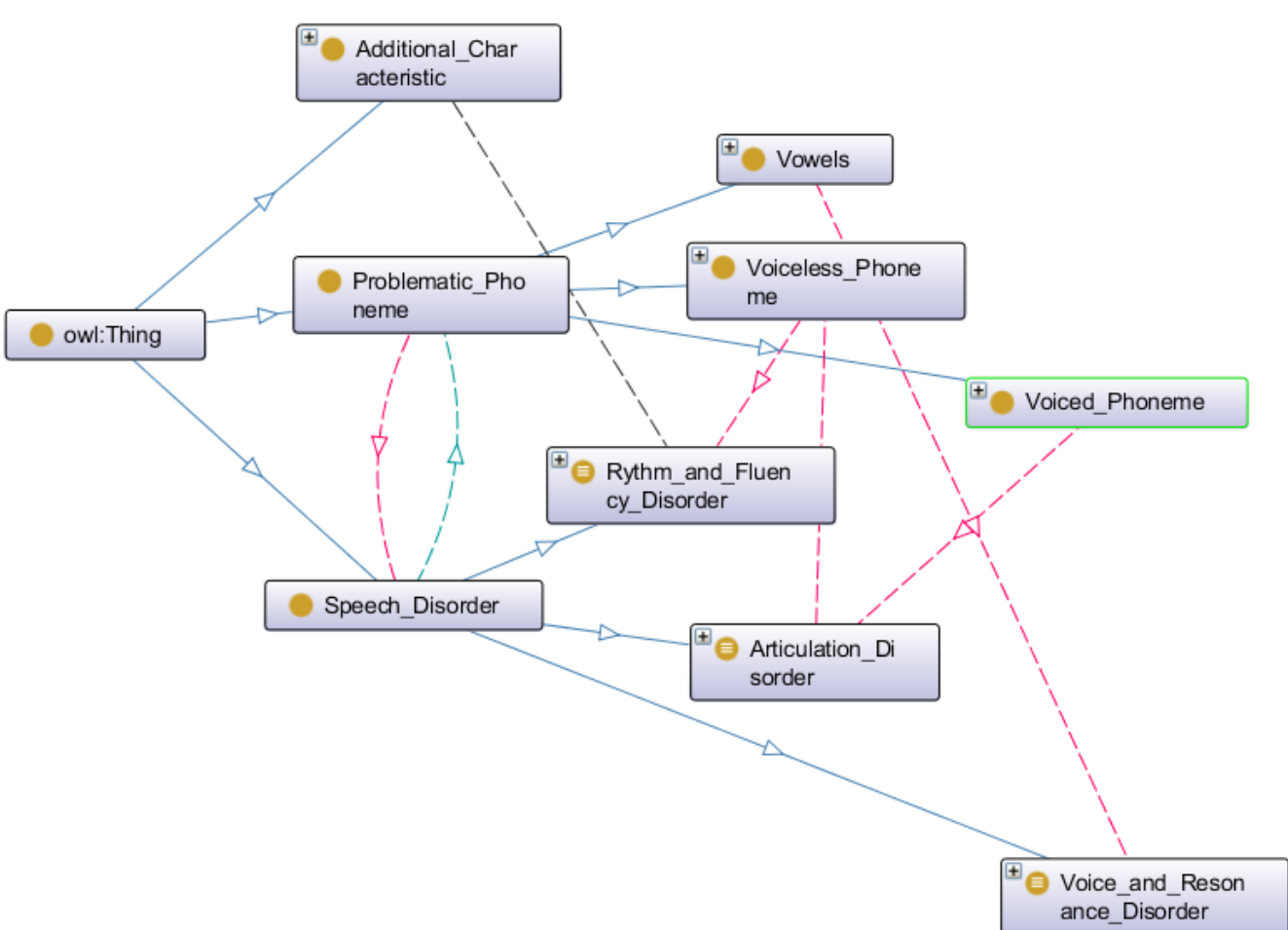


Figure 3. Non taxonomic relations (object properties) with the new added classes.

- Each set of problematic phonemes was listed as instances of subclasses Vowel, Voiced_phoneme and Voiceless_phoneme which are subclasses of Problematic_phoneme.

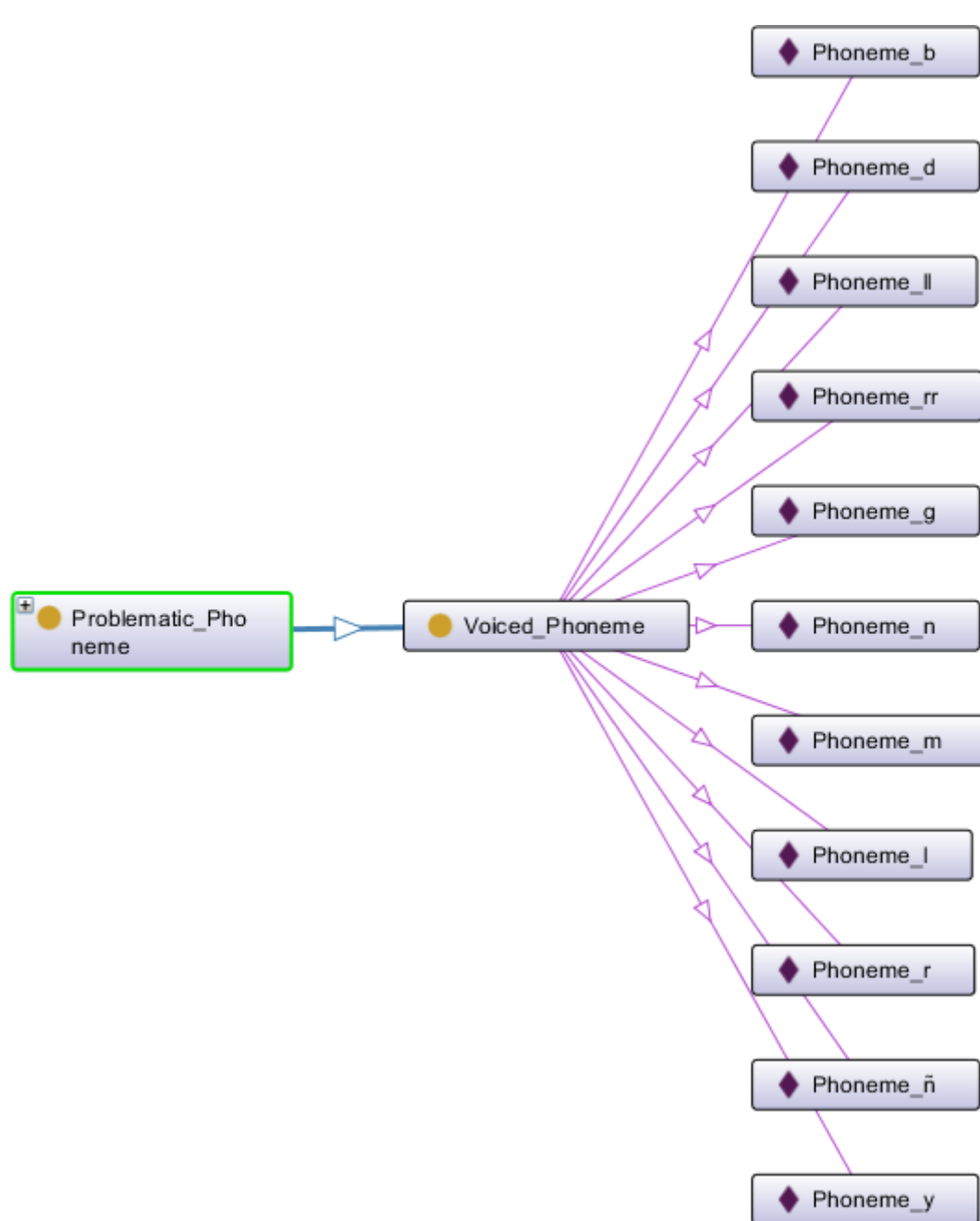


Figure 4. Class Voiced_Phoneme and its instances.

Tests results and conclusions

Languages DL Query and SPARQL Query were used to develop the tests and queries to re-trieve information from the ontology.

SPARQL

```
SELECT ?phoneme ?disorder
WHERE { ?phoneme
owl:Causes_difficulty_in ?disorder
}
```

```
SELECT ?phoneme ?disorder
WHERE { ?phoneme
owl:Causes_difficulty_in ?disorder .
FILTER regex(?phoneme, "^r")
}
```

DL Query

```
Speech_disorder(?disorder) ^
Has_difficulty_with(?disorder,
?probphoneme) → Causes_difficulty_in
(?probphoneme, ?disorder)
```

The above queries were intended to answer some of the competency questions, an ontology can produce satisfactory results firsthand when a query is made in this way.

As a result, a consistent version of the ontology was obtained, more than one hundred subclasses and several relations among the individual were identified, the existential restrictions and characteristics for the classes were set, what turned this ontology into a tool that is used for information description. The population of the ontology was made with data collected by therapists working in public institutions, such as elementary schools; the instances of the *Person* class are the individuals represented with said data.

Ongoing work

It is proposed the use of an audio transcription software, as well as analysis of said data to detect some speech disorder and its possible classification using the current ontology as a knowledge-base for this purpose.

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