

This poster describes the principal elements of a methodology - and its associated computational system - that generates graded categories of intonation contours from sets of instances belonging to these categories. At the core of the methodology are the principles of fuzzy logic [1] and the concepts of frequency and similarity [2, 3]. The goals of the method are to enable the quantitative analysis of intonation in terms of the gradience and binarity [4, 5] of its constitutive units (tones) and, from this analysis, to automatize tonal labeling of intonation contours.

In a first application, the computational system successfully extracted a prototype (an intonation contour and its graded variations) from a corpus of 714 French closed questions experimentally obtained from 7 native French speakers. The contour of French closed questions is characterized by a low plateau and a final rise: LL-H%. All sentences were controlled to be 7 syllable long.

Firstly, the system converts all instances of the contour in the dataset into a four-level hierarchical and analytical structure. The first level is the level of the acoustic raw data (fig. 1a). The second level results from the normalization of the data into a cartesian plan relatively to the instance's minima and maxima for time and f0 (100 points long in time by 100 points high in f0) (fig.1b). The third level is the level of pretones, a subset of 30 normalized points that are the extremities of tonal movements contained in time frames (fig. 1c). The time frame length has been set to a half-syllable (14 frames per sample). The fourth level is the subset of 3 pretones that are the 3 tones of the intonation contour (L, L- and H%) (fig. 1d). The components of each level exhaust the data from the level immediately under it as its composing features.

Secondly, the principles of fuzzy set theory are employed to organize the data into a graded structure of membership levels (from 1, fully included, to 0.1, almost excluded), according to the frequency of the elements in the dataset and to their level of similarity towards the central values. The data is *fuzzified*. The information from all instances is merged and fuzzified (fig. 3) by level of analysis (normalized, pretonal, tonal) to model a prototypical intonation contour and its range of variation at the pretonal and tonal levels (fig. 4 and 5).

The system can then evaluate the degree of membership of a new sentence as a closed question. The new candidate is given the same 4-level structure and its components are matched to the values stored in the model.

Because it can be adjusted to analyze any parameters or relations of parameters, the model is very flexible and is constantly improving under several versions. The model also allows to study the interaction of the ranking principles (frequency and similarity) as principles of linguistic categorization. I am currently working on a larger corpus of closed questions as well as two modalities of questions (doubt and surprise). I am also developing inferential fuzzy rules: the degree of influence of one tone on the next. The overall goal is to delve into the plasticity of intonation, as apprehended by the AM framework, by constructing an equally flexible exploratory model from which rich analysis are possible.

## References

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- [5] D. Bolinger, Intonation across languages, in *Universals of Human Language*, Volume 2 (Phonology) (J. Greenberg, ed.), pp. 471-524, Stanford: Stanford University Press, 1978.

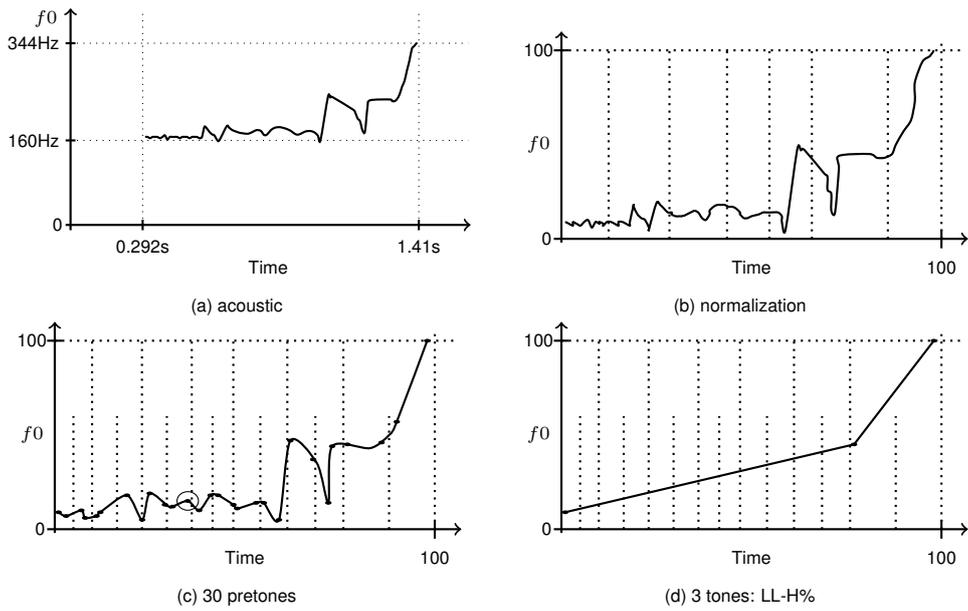


Figure 1: 4-level structure analysis of a sample: *Tu vas garder les tickets ?* (Are you going to keep the tickets?)

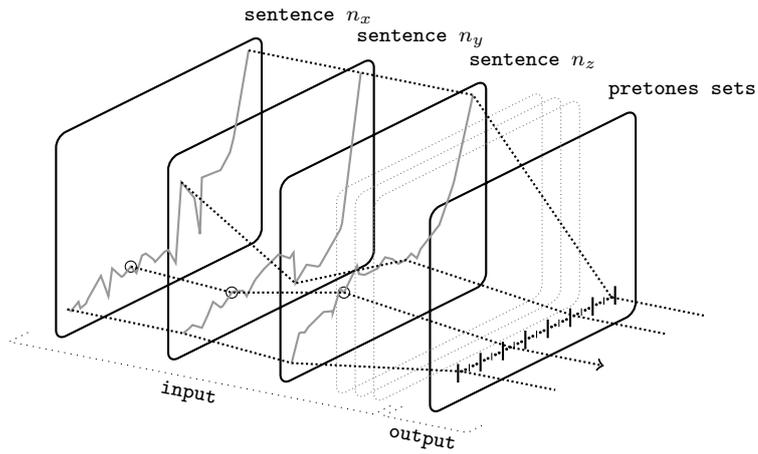


Figure 3: merging instances data through fuzzification

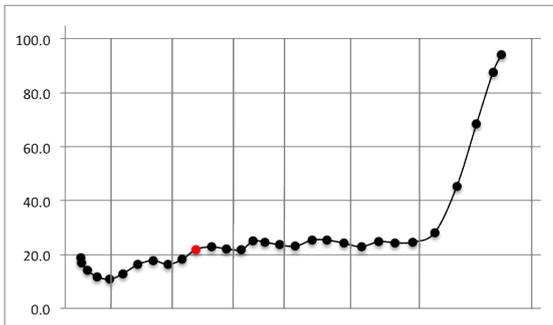


Figure 4: Prototypical pretonal contour

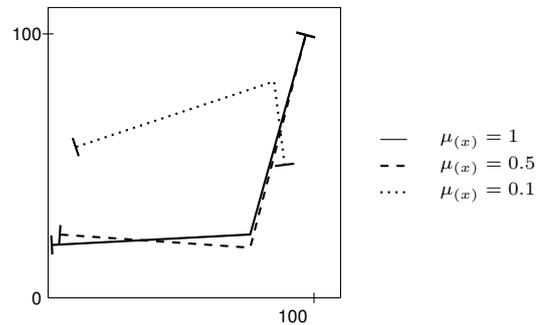


Figure 5: 3 levels of the prototypical tonal contour