Generating Membership Functions for a Noise Annoyance Model from Experimental Data

A. Verkeyn *, M. De Cock **, D. Botteldooren *, E. E. Kerre **

* Ghent University
Department of Information Technology
Sint-Pietersnieuwstraat 41, 9000 Gent, Belgium

** Ghent University
Department of Applied Mathematics and Computer Science
Krijgslaan 281 (S9), 9000 Gent, Belgium

Summary:
The success of fuzzy expert systems could be mainly attributed to the inclusion of linguistic terms into their reasoning scheme. This allows reasoning about complex issues within a certain (tolerated) degree of imprecision. Hence, an important issue in the development of such systems is the choice of the membership functions that model the linguistic terms involved in the application. In this chapter we will describe several methods for the construction of these membership functions (which represent information) from measurements obtained in psycholinguistic experiments. Special attention will be paid to the inclusive and the non-inclusive interpretation of linguistic terms. Secondly, these techniques are applied to data gathered in an International Annoyance Scaling Study, where the relationship between more than 20 different linguistic terms and their corresponding noise annoyance level was under survey.

Keywords: fuzzy expert system, linguistic term, membership function, inclusive and non-inclusive interpretation, noise annoyance

1 Introduction

People tend to express real-life information by means of natural language. It allows them to reason about everyday issues within a certain (tolerated) degree of imprecision. It is, therefore, not surprising that the introduction of the fuzzy set theory as a framework for the mathematical representation of linguistic concepts has given a rise to an important evolution in the field of computer science. The fuzzy expert systems that emerged in this context have proved to be a useful tool in many real-life applications. A fundamental issue in the development of such systems, is the design of the membership functions that model the linguistic terms involved in the application. In this chapter we will describe several methods for the construction of those functions (which represent information) from measurement results obtained in psycholinguistic experiments.

The chapter is structured as follows: after presenting the problem of noise annoyance modelling (Section 2) and describing the form of the experimental data at hand (Section 3), we will briefly recall how linguistic terms are represented in fuzzy expert systems, thereby stressing the difference between an inclusive and a non-inclusive interpretation (Section 4). The main part of this chapter is an overview of well-known, improved and new methods for the construction of membership functions; we explain in detail how they can be applied for noise annoyance terms (Sections 5, 6, 7, 8).

2 Noise Annoyance Modelling

As an environmental factor, noise has several adverse effects on man. Annoyance or disturbance is commonly used as an impact indicator for these effects. Noise surveys can be used as a measurement tool. One of the most important questions in such a survey sounds out about the level in which someone is annoyed by the noise, namely “Thinking about the last 12 months, when you were here at home, how much did noise bother, disturb, or annoy you?” If the survey is conducted by telephone, the subjects are given a set of linguistic terms to choose from: e.g. *not at all annoyed*, *slightly annoyed*, *very annoyed*,... Throughout this chapter we will refer to the linguistic terms that are generated by applying an adverb to the base term *annoyed* as **annoyance terms**. In postal or face-to-face surveys, a numerical or graphical scale can be used. Even in this case the question must be asked whether the mark on a numerical or graphical scale is not a forced expression of a feeling that is more easily expressed using natural language.

The goal of an annoyance model is to predict the outcome of annoyance surveys. Such models can be used by noise policy makers to make strategic decisions. For instance, they can help to choose the “best” route for a new railway by comparing the predicted level of annoyance that the population living along two different possible routes will experience. Fuzzy techniques are very well suited for this modelling purpose: it is far more easy for humans to express annoyance by means of a linguistic term - which is intrinsically vague - than by some crisp number.

The output of a linguistic noise annoyance model will be a noise annoyance term. The input can be either crisp or vague facts. Examples of crisp facts that may influence noise annoyance are age, number of children under 18, average daytime noise exposure level, average nighttime noise exposure level, etc. An example of a

Because of copyright issues, the paper is not presented here in its full version. If you want to obtain a copy, please send an e-mail to Martine.DeCock@UGent.be