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INFLUENCE OF ACTIVITY PATTERN ON NOISE EXPOSURE AND EFFECTS OF NOISE

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ABSTRACT

Classical annoyance assessment is based on averaged façade noise level. Large variations are nevertheless observed in the response of individuals to noise annoyance questionnaires even when exposed to a similar façade noise level. These variations can be attributed to personal factors, such as noise sensitivity, but also to factors of acoustic and context nature.

The work reported on in this paper proposes to use information on typical activity patterns and mobility to improve noise effect modelling. It is part of a more general effort to model effects of noise starting from known psycho-acoustic and psychological principles. Noticing noise events plays a crucial role in this model.

The simulation framework that is added in this work allows monitoring real noise exposure of individuals over time as they move through the environment. Activity can also change other parameters of the model such as the attention level. These time varying quantities are strongly linked. Activity patterns also have a strong influence on context through the locations people visit and the social interactions they experience. A multiple-agent model allows investigating the possible influence of context adaptation. Simulation results are presented illustrating how the model can be applied in real situations.

1 INTRODUCTION

The bulk of literature on noise annoyance and other effects of noise on man has focussed on extracting relationships from epidemiologic research in a “blind” way, that is without ab initio assumptions about the underlying mechanisms. In many scientific disciplines, a different approach is quite common: a model is constructed from available knowledge including acceptable hypothesis and the value of this model is measured by its ability to predict or explain the observations. Such a model is considered valid until an experiment is found that is inconsistent with this model. In an effort to follow this angle of attack in noise effect research, we started to develop a model starting from known acoustic, psychoacoustic, and psychological principles [3][4]. This model works on an individual basis. This means that, to produce the average effect in a population, a large sample of individuals has to be modelled. Noticing of sound events is the initial and crucial step in this individual model. It triggers a whole sequence of events that include emotional and cognitive reactions as well as adaptation and coping. Personal factors such as noise sensitivity, coping style, etc. are included by sampling a realisation of a modelled individual from known probability distributions of these factors.

Activity plays a crucial role in the model. Activity first of all determines alertness, an important part of the event noticing model. It also determines has however also an effect on self-produced noise by the activity that may be masking environmental noise. Activity also relates to location (at home or not, indoor/outdoor) and thus to changes in exposure to environmental noise.

In the previously developed model, the modelled individuals were immobile. For exposure purposes, they were located at their dwelling and were assumed free of noticing events while away from home. The current paper reports on a first step in treating the modelled individuals as mobile agents, their mobility and location being determined by the activity. Making the modelled individual mobile opens a range of possibilities. Firstly real long term exposure can be modelled more realistically. Although there have been some reports on the importance of the neighbourhood soundscape [5] on noise effects, the direct effect of exposure further away from home is expected to be limited. Indirect effects may include the modification of frame of reference for judging ones own exposure situation. Secondly, moving individuals meet others and thus the effect of interactions can be included in the model. Because of interactions, opinions may be exchanged and this may influence personal factors such as noise sensitivity or beliefs such as environmental worry that could influence the modelled individuals emotional and cognitive reactions to noise.

In this paper, an agent-based approach is proposed. It allows easy modelling two kinds of interactions, those with the (acoustic) environment and those between agents. Daily activity patterns and transport information form the input for this model. Thus far, we only have the possibility to include the results of this model as an input to the noise annoyance model that was previously developed. Full two-way coupling is envisaged in future.

2 INFLUENCE OF ACTIVITY PATTERNS

2.1 Overview

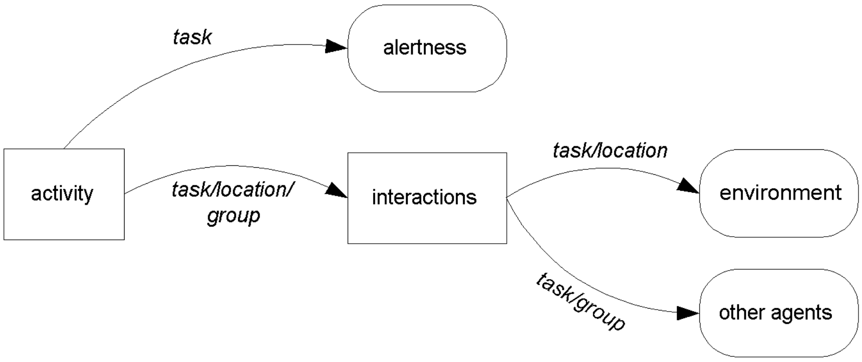

Fig. 1. Influence of the activity of an agent.

An activity pattern defines the series of activities an individual executes. Activities are typically associated with a certain task or occupation at a certain location at a given time, possibly together with other individuals. Figure 1 shows the direct influences of the activity on a selection of parameters typically used in an agent-based approach.

2.2 Alertness

The concept of *alertness* specifies the alertness to noise and reflects that within the human mind only a limited amount of resources is available. When multiple inputs are presented, attention is divided amongst them based on the task and goals at hand. During an activity requiring significant mental resources the alertness to noise is likely to be lower. On the other hand, during relaxing, an elevated alertness to noise is expected because few other stimuli are presented. In addition alertness in general fluctuates during the day with an absolute low during sleep. In the model, alertness influences the perception of intruding noise.

2.3 Environment interaction

The interaction with the environment is a term used to define any influence the environment has on the modelled individual and vice versa. The influence of interest here is the environmental noise in the neighbourhood and at other locations where the individual may reside. In a more elaborate model other stimuli such as odour and visual appearance **Fout! Verwijzingsbron niet gevonden.** can be considered.

In addition to the directly stressing or restoring effect the environment may have, it also creates a multitude of past experiences that help to ground a *frame of reference* used in future evaluation of environment related subjects such as assessing the quality of the living environment or more general subjective wellbeing. An individual living in a quiet area is almost certainly aware of this fact. Assuming that most individuals, due to the increased mobility, frequent sufficient locations means that they are exposed to a broad range of environmental noise. This helps them to build a *frame of reference* for evaluating noise.

2.4 Agent interaction

The responses of an agent to environmental noise are not only a matter of the individual. They are also determined by interactions between agents. The modeled individual gets a perception of his or her situation within the local society via interactions with others.

The frame of reference mentioned before is not only build based on own experience but also on reported experiences transferred from other agents in the pool of modeled individuals.

As reported by some authors [2], the point of view with respect to environmental issues of an individual plays a role in the evaluation of environmental stimuli. In questionnaires this factor is queried by asking how respondents feel about the importance of different environmental aspects in their life or the community. Examples of such aspects are global climate change or air pollution. These questions measure the *environmental worry*. It is to be expected that this view is influenced by communication with other agents. We can categorize the different views as opinions and subsequently use an *opinion-model* [1] to model the propagation of opinions through a community. In this framework we can also view the media as an agent. Opinion models study in detail the conditions under which an opinion can be transferred, e.g. the opinion of the agent may not be too different [1].

3 AGENT MOVEMENT

Agent interaction is primordially a consequence of two or more agents meeting each other and communicating with each other. The movement of agents can be modelled at different levels of detail:

1. Low level spatio-temporal modelling: the position of each agent is updated after a certain small amount of time, typically a second to a few seconds, and the position is given in real-world coordinates.
2. High level spatio-temporal modelling: the location of an agent is defined more vaguely and time advances at the rate the agents move from one abstract location to another. Examples of locations are: “at home in the living room”, “at work”, “in a park”, …

It is clear that approach 1 demands a much higher effort in modelling but can lead to more accurate results. It is approach 2 that is proposed in this paper. It also forms the starting point of a more detailed model such as given in approach 1 for particular sub-areas, e.g. the neighbourhood of the house. A further simplification applied to the model is that the actual movement itself is not modelled, in particular the movement by car or any motorized vehicle. We assume that the stimuli during this activity do not depend on the location of the vehicle. Even with these assumptions, modelling of location remains a two-level process where a distinction is made between smaller spatial cells such as buildings, and larger cells such as villages or urban districts.

Movement between the larger cells is extracted from traffic data. The O/D-matrices (origin-destination-matrices) [6] form the starting point for the distribution of movements. They state how many movements are made each hour from one zone to another. Figure 2 (left) shows an example of the zones used in the traffic model for the area of the example given below. Zones shown in red and squares have a direct connection to a highway. Not all people have the same activity pattern nor the same travelling behaviour. Therefore the information of the traffic model needs to be linked to demographic data. Employed people will typically have a different daily movement pattern than unemployed or retired people.

An important aspect is that people tend to visit the same area day after day. In practice, this means that an agent which start from a zone A and goes to zone B on a particular day, will very likely be doing the same movement the next day. The destination zone for an agent is not random and this needs to be taken into account. An agent has a so called *zone-affinity*.

A consequence of this behaviour is that there emerges some grouping of agents into zones and interaction gets focussed on this particular group.

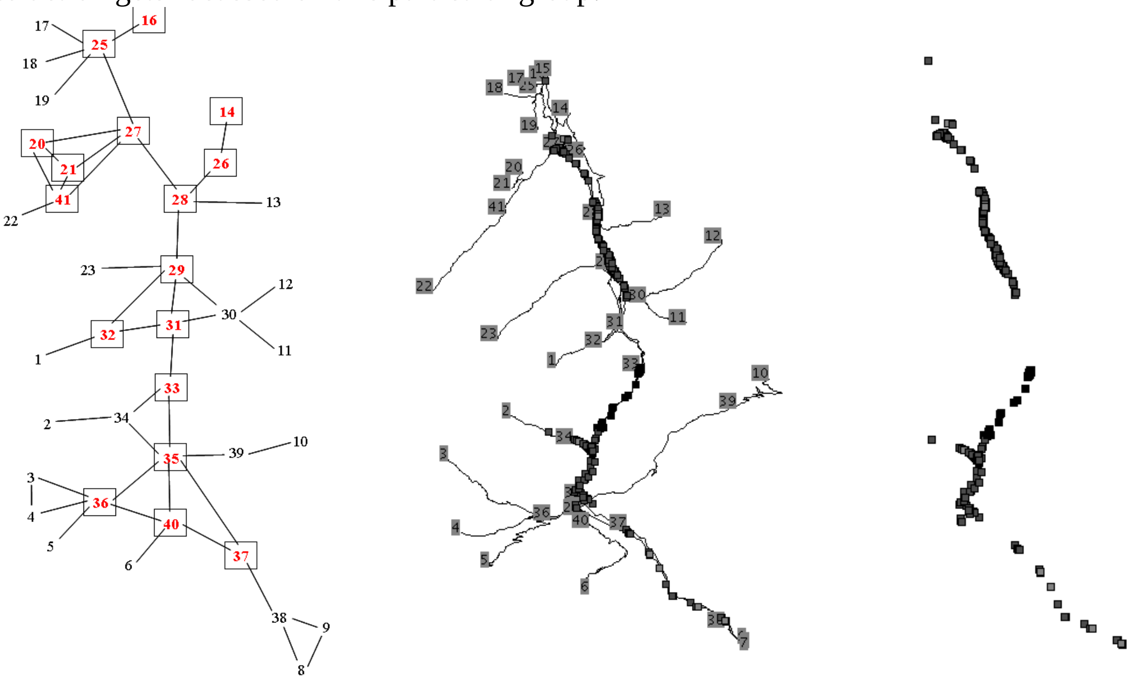

Fig. 2. Traffic zones in the study area (left), agents exposed to a daily averaged $L_{eq,\,24h}$ above 65dBA plotted at their home (right),and the same data with road network and zones as background (middle).

4 FIRST SIMULATION RESULTS

This section discusses some of the first results obtained by the moving agent model. The region under study is shown in Figure 2. The area has a typical build-up: a large central valley containing a highway where the main roads of the side-valleys connect to. The O/D matrices used to study this area contained information about hourly movements for the about 40 zones. Following key assumptions were made about the movement of agents:

1. Each agents returns to its *home* zone within 24 hours.
2. The area is small enough for every zone to be reachable within the hour.
3. Any change of location takes at least 1 hour.

The number of modeled agents totaled 44022 which match the number of inhabitants of the area. The agents were distributed among the different zones proportionally to the real number of inhabitants of that zone. For simplicity all agents were assumed equal.

During the simulation the noise levels of all the zones an agent visited were recorded. Noise level information (L_{Aeq}) is available for each hour of the day. It is based on the road traffic generated by a traffic model using the same O/D matrices as the agent model. In total a little over 20% of the population changed location during the day while they consumed 40% of all available trips stored in the O/D matrices. This low percentage is due to the fact that a lot of the trips contained within the O/D matrices are caused by through traffic which is not modeled. The middle and right map of Figure 2 show the agents (at their home) which were

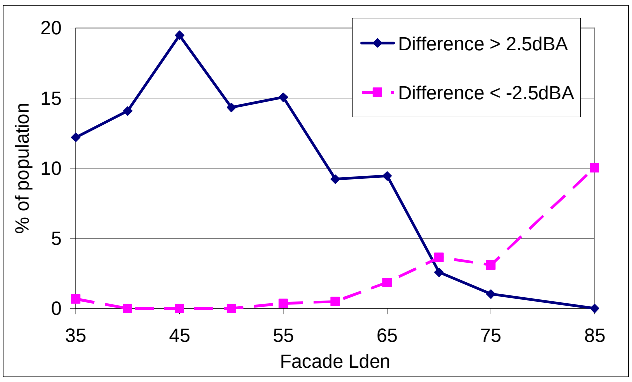

Fig. 3. Percentage of people experiencing higher / lower exposure to noise during their movement than at home.

exposed to levels above 65dBA L_{den}. This number totals roughly 18% of the total population, while based on the façade levels 14% was found. More interestingly is the relation between the noise level at locations visited and the level at home. Figure 3 shows the percentage of the population that is exposed to noise levels more than 2.5 dBA higher than the L_{den} at home and the percentage of the population exposed at levels 2.5 dBA lower than at home. It is typical for this location that many people travel to noisier places during their daily activities.

5 CONCLUSIONS

In this paper we have discussed how daily activity patterns of individuals could influence their reaction to different environmental stressors and in particular to environmental noise. We have shown how information from a traffic model can be used to set up a model of agents which move through the environment. By their movement they experience a different exposure to noise than is estimated using the façade level. This can influence the effects but also the frame of reference used in assessing exposure. They also get the opportunity to meet and exchange opinion (in particular about environmental issues and noise). In future work, we will couple this moving agent model to the effects model that was previously derived and investigate how these interactions can influence reactions of people to noise exposure.

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