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USP-E0361 Complex Adaptive Systems

Model Description Sheet

1. Starting point and the development of the code

The developed model was built on the basis of several existing toy models presented within the GAMA Platform together with the elements of tutorials and open-source samples of codes. One of the fundamental models was the Simple Traffic model, in which pollution was shown to be dependent on the number of agents on the road. This is the core idea underlying the basic principle of how the model that we have works. It was largely modified as our team was interested in investigating the noise pollution that is not just randomly generated to display emission effects that vehicles produce, but bring them as close to the real numbers as possible by incorporating the correct parameters, and observe the behavior of car pollution on the surrounding environment - the green areas. All of this was done according to the information found in the Internet regarding the noise emissions from vehicles in an urban setting and their specificities addressed to the density of each road. Later on, to make the visual effect of the simulation more apparent and concrete, two more methods of graphic representation were added to the code - a pie chart (to get familiar with exact percentages of change) and a series chart (to observe the characteristics of the ongoing and constantly changing process as a flow).

2. Model Description

A big portion of the utilized files within the constructed model were prepared beforehand in QGIS; websites with open data gave access to the information that was useful in the process - like the map of the chosen location within city (Eastern Helsinki), the exact location of roads, traffic amounts, green areas and the contour of buildings. The road weights are calculated by their capacity, which is derived from the amount of the cars on the road and their speed. Moreover, cars' speed is updated at each cycle according to the traffic density. The classification and placement of the original agents within the Simple Traffic Model was adjusted to create a logical pattern in their movement and reduce the factor of randomness. In order to explain the principles of the created model examining noise pollution effect on green areas, the code was divided into several comprehensible parts:

Environment:

Many of the used QGIS shapefiles were modified even before being transferred into GAMA. For example, in order to investigate in detail the approximate radius of noise from cars, the mentioned shapefile of the existing green areas was converted into a grid before exporting into GAMA Platform. This gave flexibility in structuring the code according to our own understanding (described in the following section). Such a scheme allowed for more controlled changes within each cycle (because we are considering the behavior of pollution after the car is leaving each of the grid cells, we are reducing noise pollution by 30% after each cycle (although the percent is adjustable)).

Seeding:

The cycle starts with 1000 people agents (the amount can vary) being placed at a certain location (wasn't identified in any of the toy models that were used for the structure of the code as a reference): one of the two categories prepared in QGIS beforehand - the residential buildings. For each imported shape of buildings, the probability model was used to identify the possible percentage of agents leaving their building and going to the business/residential building, while their route back to the location they started from is calculated by the path generating function. The percentage of the agents entering business buildings is set to be higher (but is adjustable).

Whenever any of the agents moves, it enters the road network (the imported GIS shapefile). With each new cycle, every cell in the grid is being asked whether it has any overlapping agents. At this stage the mentioned agents are categorized into roads, green areas and cars, and are measured by their amount. Also the average of speed coefficients of cars in each road is considered.

The main element within the created pollution model lies within the following formula (structured with a case syntax):

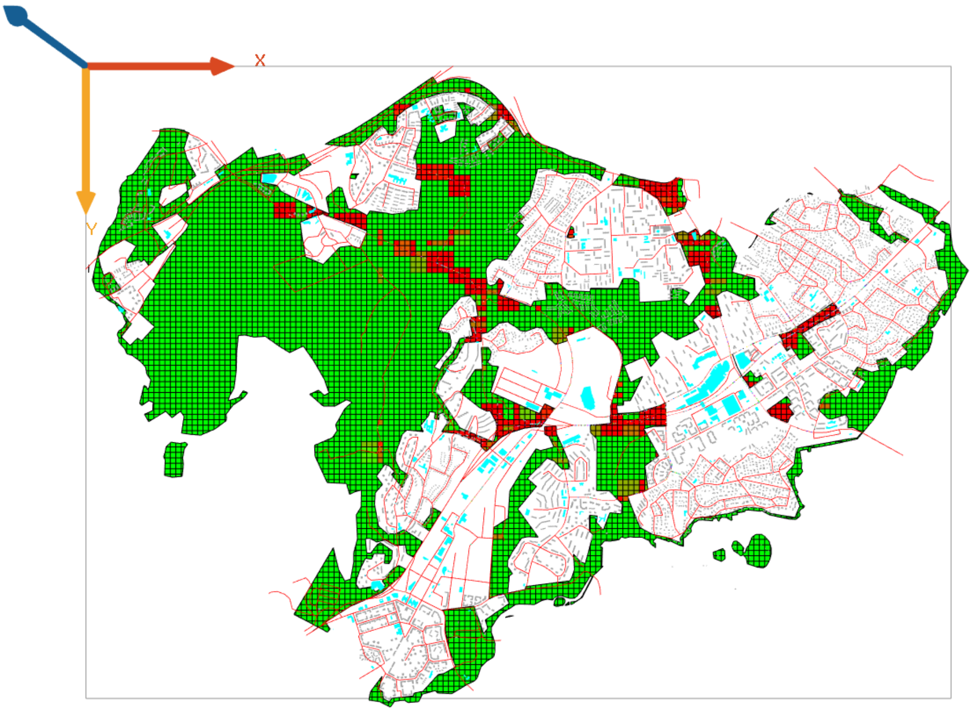
The average noise coefficient for the cars in the developed model corresponds to findings from CPR Environmental Education Centre (2019), in which the average noise pollution of an urban car traffic is equal to 60-65 Db. Consequently, a green area is considered to be contaminated in the case if the noise pollution is over 75 Db.

In case there is only one passing car within a cell, the noise increases up to 15 (60 - 45, in which 60 corresponds to the average car traffic noise in urban areas; and 45 represents the average noise level in the silence zone (CPR Environmental Education Centre, 2019)).

However, in the scenario, in which there is more than one car within a cell, each of the additional cars adds 5 Db to the overall noise pollution.

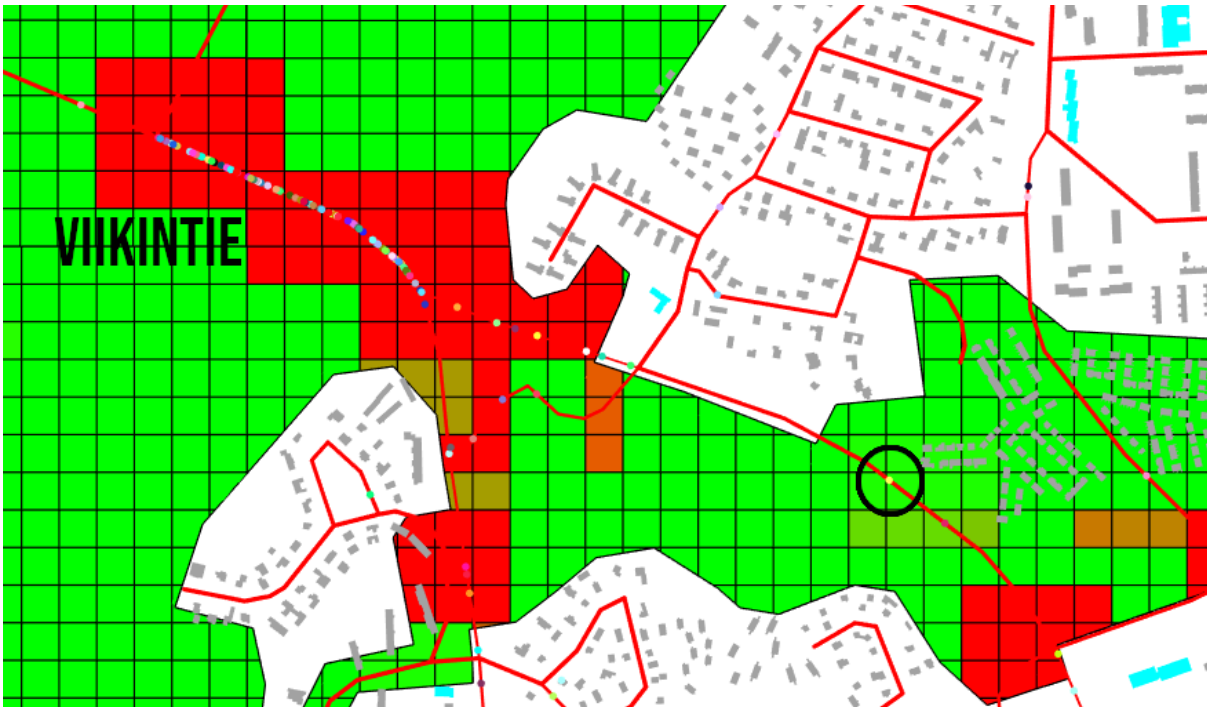
The received data about the pollution level of each cell is utilized for the structuring of charts. The calculated percentage appears as polluted (and colored with red) based on the amount of cells that are considered 'polluted' (the cells, in which pollution level is over 75 Db).

3. Findings



The noise pollution model (around 280 cycles)

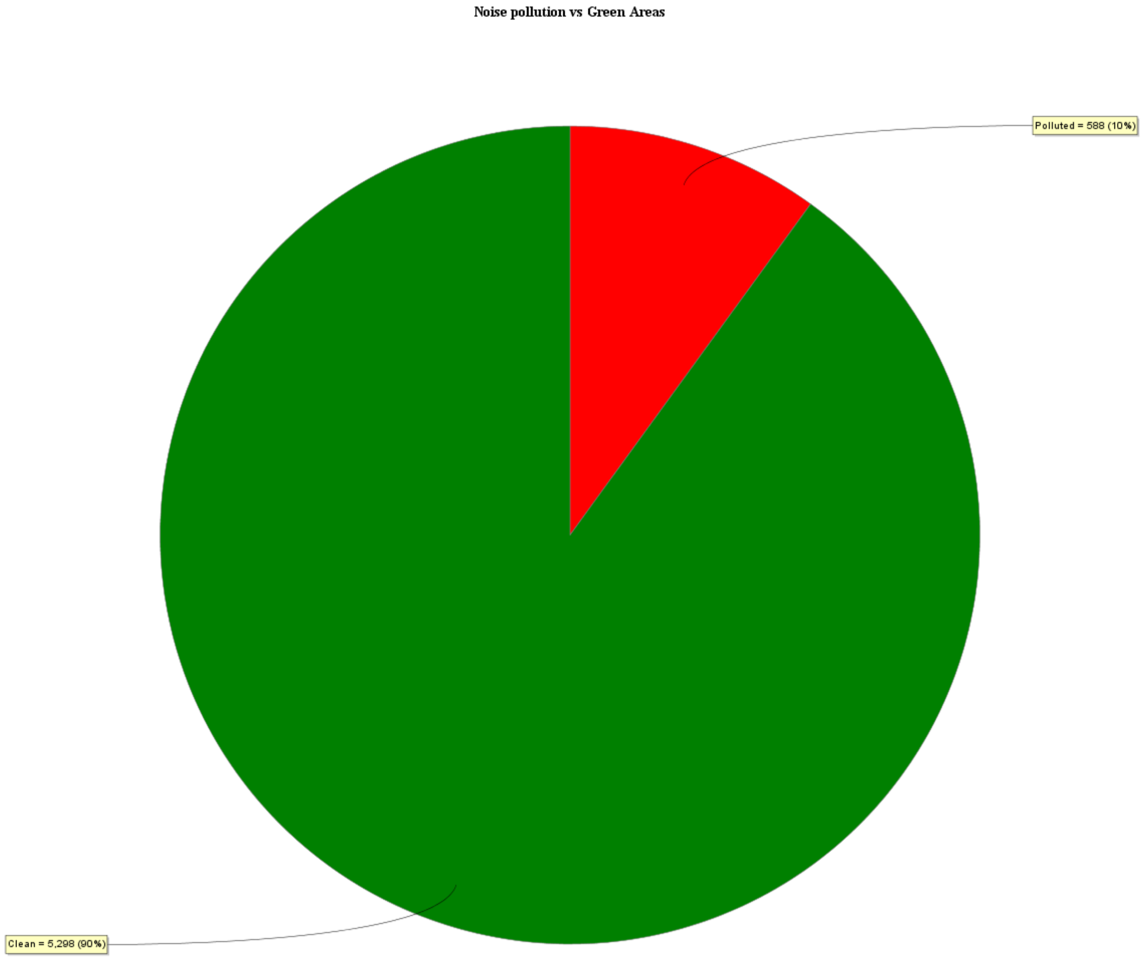
Our model shows and measures the noise pollution that is affecting the green areas that are located near traffic routes. As we have defined the behaviour of the people and car agents to move from residential buildings to commercial/business buildings in the area of Vartioharju it was surprising that the roads that are congested and busy in real life were also most polluted in the model. In a way it seemed that the model was representing the real world and the traffic that is happening in Vartioharju. The busiest (and the noisiest) roads in the model were Itäväylä and Viikintie.
When it came to visualising the data it was interesting to see how the big noise clusters emerged in the busy roads, and while the car agents happened to cross/intersect each other the green grid was affected on a larger scale even though every car only adds 15 db. The effect of multiple cars is visible in the picture below: the car-agents on Viikintie have a manifold effect on the green areas while the single car inside the black circle doesn't seem to have any noise pollution effect on its surroundings.



The noise pollution model (around 140 cycles)

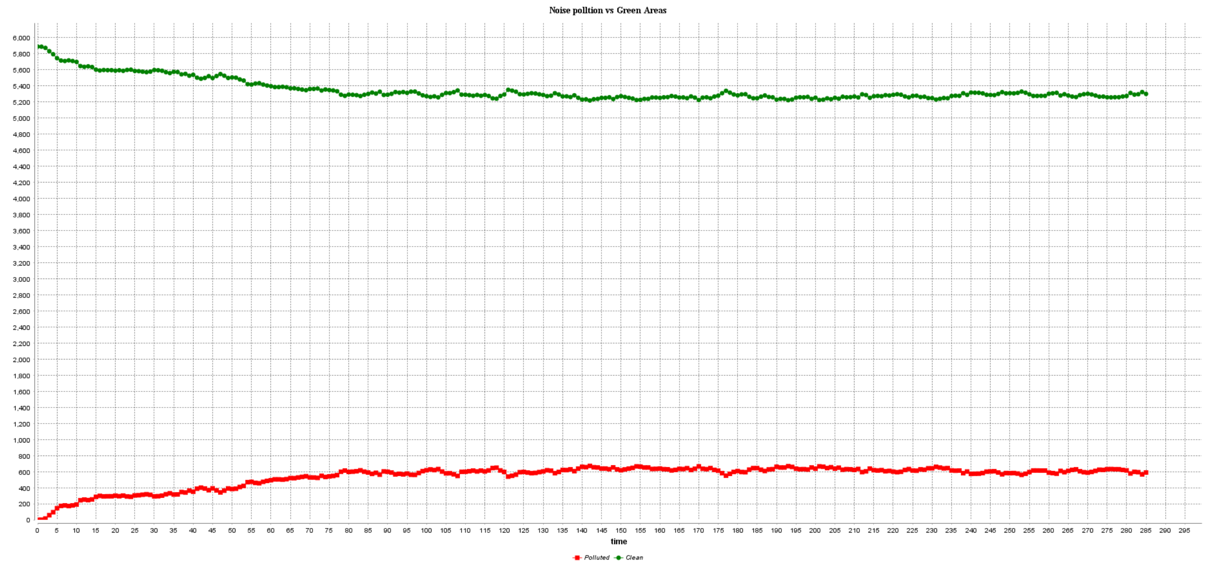
When it comes to measuring the noise pollution of the green areas it was interesting to see that the rate of polluted and clean areas seemed to vary between 5-11% of polluted and 89-95% of clean green areas, but after about 120 cycles the numbers settled at 9-11% of polluted green cells and 89-91% non-polluted green cells. Even though there were a lot of agents moving, most of the green areas in Vartioharju were unaffected by noise pollution.

The series chart displayed the ongoing development and change of the polluted and clean areas on a timeline. It visualised the constant movement and balance of these two measures in a more understandable way, while the pie chart visualized the percentages in a more tangible way.



The pie chart of the noise pollution model (around 280 cycles)

When examining the situation within the percentage of polluted green areas vs non-polluted, it may be observed that despite the observed changes in pollution that take place in the displayed site, the larger portion of green areas is remaining clean (90%). Whereas the amount of contaminated areas stays 9 times less than the clean areas.



The series chart of the noise pollution model (around 280 cycles)

For more precise examination, a series chart was added to the overall range of graphic visualizations.

Here, the slope displaying tendencies of both categories exhibits a varying condition. The curve representing clean areas shows a gradual decline from 0 to 85 cycles, after which it stays within a uniform range of the noise pollution level. At the same time, polluted areas showcase a smooth rise in pollution levels up to 80-85 cycles. Afterwards, the oscillation level is shortened and kept within the same range as well.

This example teaches that for the most specific and realistic outcomes, several ways of displaying results during any simulation is required.

We came to the conclusion that the created noise pollution model could be useful for pointing out the most affected areas and taking action in decreasing the effects of it in certain places. It is also a tool for modeling and visualising the amounts and scale(s) of noise pollution in specific locations with certain typologies. Additionally, it can assist a lot in observing the changes that will be brought into the environment with each constructed road (if the municipality of the district has planned for any in the near future), and by that help in creating a more environmentally friendly neighborhood, in which ecosystems coexist well with the human-dominated environment.

As for the further possible improvements, the model could consider the other types of vehicles, some of which might be generating noise pollution at a different rate (the hybrid cars, motorcycles, trucks etc.). If these conditions were taken into account, the diffusion rate would vary in the overall appearance of the model as well, displaying a more realistic case.

References:

CPR Environmental Education Centre. (2019). *Noise Pollution*. Vikaspedia. https://vikaspedia.in/energy/environment/know-your-environment/pollution/noise-pollution

Skrucany, Tomas & Šarkan, Branislav & Figlus, Tomasz & Synák, František & Vrábel, Ján. (2017). Measuring of noise emitted by moving vehicles. MATEC Web of Conferences. 107. 00072. 10.1051/matecconf/201710700072.