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APPLICATION OF ARTIFICIAL INTELLIGENCE IN SETTLEMENT DEVELOPMENT MODELING

Kozák Luca
BSc hallgató, Matematikai Intézet
3515 Miskolc, Miskolc-Egyetemváros, e-mail: lucckozak@gmail.com

Házy Attila
egyetemi docens, Matematikai Intézet
3515 Miskolc, Miskolc-Egyetemváros, e-mail: matha@uni-miskolc.hu

Veres Laura
egyetemi docens, Matematikai Intézet
3515 Miskolc, Miskolc-Egyetemváros, e-mail: matlaura@uni-miskolc.hu

Abstract

In the book (Házy-Veres et al., 2020), we presented a model that applies artificial intelligence and neuro-fuzzy systems to the settlement development. The model is based on the creation of two knowledge bases, databases: one a database of good practices and a second one of settlements. Based on this result we created a web-based application to measure the social innovation potential of settlements and support implementing good practices.

Keywords: *artificial intelligence, settlement development, database management, web-based application*

1. Introduction

When we hear the word innovation, we usually think of technical or economic innovations; however, social innovation is also prominent nowadays. Social innovation results in improved quality of life and the potential to increase life expectancy. (Phills et al., 2008) It is not sufficient to carry out an economic and a technical/scientific innovation separately, but it is crucial to use the both of them in order to achieve progress. In all fields, cooperation between disciplines is inevitable for development and progress.

The social, economic and environmental challenges that society will be facing in the coming years will force governments, companies and citizens to find responsible, fast and creative solutions to their everyday problems.

"Innovations in economics and natural sciences create social problems that can only be solved by social innovations" (Kocziszky et al., 2017).

Today's society is evolving at a rapid pace, but this rate of development is unsustainable in the long term. Innovation plays a vital role in this process, sustainable development can only be achieved through a multitude of innovative ideas.

2. Good Practices

In the book (Házy-Veres et al., 2020), a model was presented that is perfectly suited for the development of settlements, but for now, it has been applied for a specific settlement. The model is based on the creation of two knowledge bases, databases: one a database of good practices and a second one of settlements.

A good practice is a proven method for carrying out a specific activity, event, process, action, or use of a tool efficiently and effectively, which can be sustained and thus further developed, and whose process and results can be documented. The definition of a good practice includes the requirement of replicability and the possibility of a broad range of adaptability (Házy-Veres et al., 2020).
Good practice is nothing more than an innovation that has already been implemented. Innovations are all around us, constantly shaping our lives, occurring in most segments of the society. A renaissance in energy use is also taking place, given the scarcity of fossil fuels and the emergence of many more sustainable alternatives. Agriculture, education, services and retail are also being transformed.

Today's societies need to think in innovative ways, creating a new strategy that reflects this. There has never been a time when it has been easier to innovate, when it has been easier to implement good practices, because we have the tools provided by the technological advances. It offers new tools that revolutionise the way society works. (Guerra, 2020; Reveredo, 2017; Rappai, 2010; soschildrensvillage.org; youth2youth.hu; wififalu.blog.hu)

The model mentioned above is based on a neuro-fuzzy Falcon model, which aims to find good practices in a settlement where they can be applied, and vice versa, to find good practices that can be applied on a settlement.

It can be seen that we are working with a large amount of data in each case, so it is important to categorise both good practices and municipalities according to several criteria and different classes.

3. Structure of the knowledge base

Expert systems usually work based on a knowledge base (database) built with if-then rules. The logical symbols of rules follow the BOOLE algebraic structure. During designing the application, the priority was to create a database containing good practices, including their categorisation and official statistics of the settlements. (Retter, 2006; Kása-Réthi, 2017; Kóczy, 2012)

Databases are primarily relational databases: they contain records along with their structure, fields and attributes, connected with logical relations, dependencies and additional attributes, in our case, fuzzy functions since the model is based on a neuro-fuzzy model called the Falcon Method (Házy-Veres et al., 2020). The attributes can be the age structure of the population, education level, marital status, income; it is helpful to specify as many attributes as possible. The more attributes we know, the more refined the classification can be.

Since this data can easily change, features are required to add new elements or modify elements stored in the knowledge base. In addition, the ability to categorise the uploaded data can be implemented and also an annotative subsystem to aid the development process. These types of databases are behind of the most knowledge-based, expert and decision support systems.

The *Figure 1.* shows the structure of our databases.

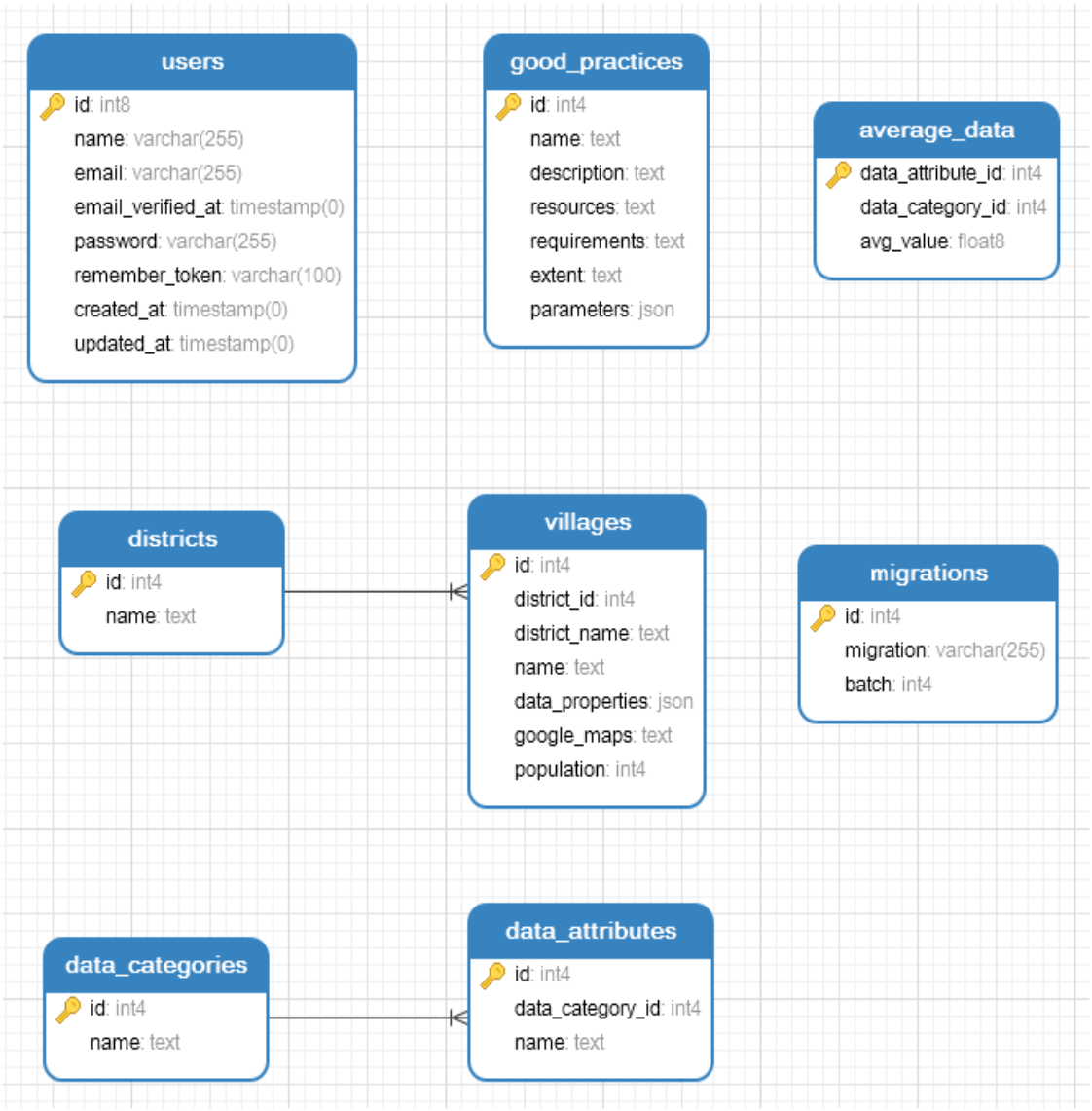

Figure 1. *Structure of the databases tables.*
Source: own editing

3.1. Structure of the database tables

The knowledge base requires the creation of a relational database that stores the relationships between different data. The creation of the database consists of three main steps. The first step is to design the database and then categorise the collected data, i.e. to separate the related data and organise it into several tables. This results in a more transparent system.

The standard SQL (Structured Query Language) language was used to create and manage the relational database. For each database table, Eloquent (which is an object-relational mapper) assigns a corresponding "model" to interact with that table.

Relationships between tables can be created using SQL queries. It is necessary to separate settlement's data and good practice's data, as the two need to be handled separately, for example, when uploading a new item or editing an item. The tables are grouped as follows:

- users table
  - Stores user (admin) data
- data_categories table
  - This table contains the names of the data categories, which are used to categorise settlements
  - For example: Basic data, Educational data, Religions, Nationality, etc.
- data_attributes table
  - Each record stored here belongs to a specific category.
  - Their role is to define the data within a category.
  - For example, the data_category_id is linked to the data_categories table.
- villages table
  - Table to store the data on the settlements.
  - The name of the associated district is stored separately.
  - The data_properties field stores the data for the settlement, which is compiled using the data_categories and data_attributes tables.
- good_practices table
  - We use this table to store the Good Practices we have created.
- average_data table
  - It contains a set of data that can be used to determine whether a given settlement satisfies the parameters of good practice and vice versa.
- districts table
  - It contains the list of the districts for which we connect the villages.
- migrations table
  - Laravel's default migration alter table, used to expressively create, and modify tables.

4. Implementation

A web-based application has been created to measure the social innovation potential of settlements and support implementing good practices.

Earlier, the replicability of good practices had been studied by humans, soon, artificial intelligence-based web applications will make the implementation process more efficiently. The main technologies used for the web application were the PHP programming language, Laravel framework, PostgreSQL database manager. (Hellendoorn, 1997; Mukaidono, 2001; Russel-Norvig, 2005)

The functions of the application learn and act similarly as a human brain. An application based on a fuzzy system can be trained and fine-tuned for scaling, which is essential for social innovation and settlement development. The vast amount of (statistical) data of the uploaded villages and good practices can be managed in different ways. There is an input, an output, and a set of rules, which the user can access (by choosing the previously given parameters). The analysis criteria can be extended and modified so that the system is constantly evolving instead of staying in a static state.

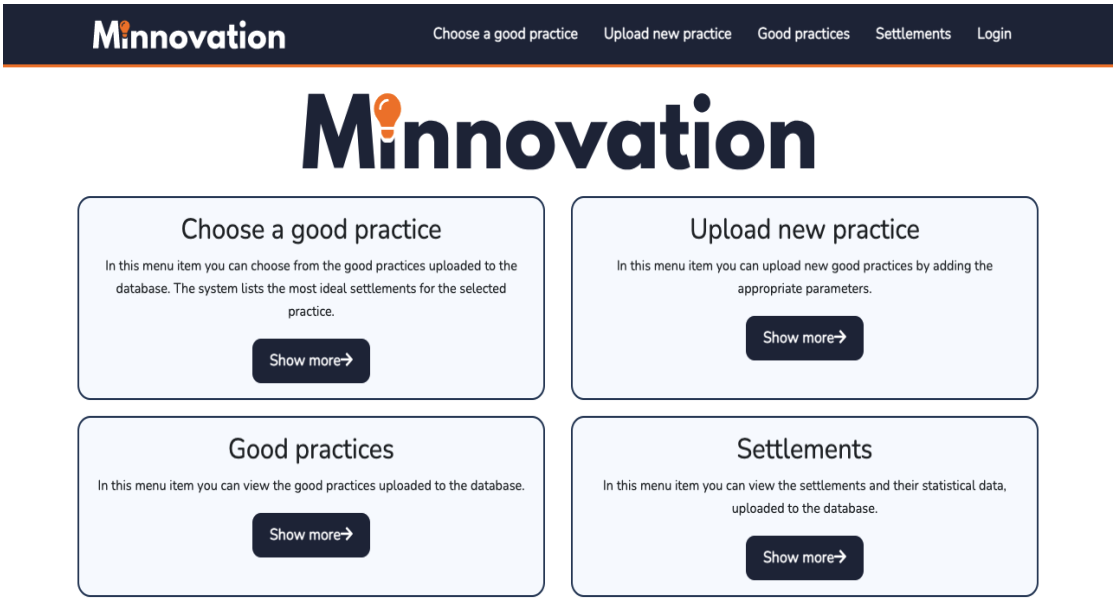

Figure 2. *The homepage of the web application.*
Source: own editing

4.1. Features

Social innovations usually take place in unique circumstances, but they can again be repeated in other settlements with similar parameters. To examine replicability of a good practice, a weighting system is needed that takes into account the different characteristics of the settlements and good practices under consideration. Using the calculations of the Falcon model (Házy-Veres et al.,2020), the program can generate an approximate result based on the parameters provided by the user and comparing them with the statistical data of the available settlements.

Using the application, the user can select an uploaded good practice from the database or implement a new good practice with the knowledge of the corresponding categories. Reversing this logic also works, i.e. the user can select a settlement from the database and the application will list the most suitable good practice known to it.

There is also a need for different modules, for instance to view the statistical data of a settlement. The characteristics of a settlement can change significantly over the years. For this reason, an interface has been implemented within the application, through which the user can update and edit the data stored in the database.

It is essential that the database is not accessible by anyone, therefore an admin interface is available to allow editing of the model. Anyone can view the uploaded good practices and settlements, perform calculations and experiment with the functions and features of the application. If a user comes up with a new innovation, the user can upload it with its own parameters and test it on the settlements available in the database.

4.2. The web application

The user can specify a number of parameters when uploading the good practice, based on which the program will later perform the calculations. For example, if the good practice is targeted at young people, one of the parameters will be "Number of young people" → high. When the user decides to examine the uploaded good practice in the future, the program will look at the percentage of young people in all settlements involved. Based on the result, it will rank the settlements, and if the percentage of young people in a settlement is above the median, then that settlement is considered to have a high percentage of young people. By analysing a number of different parameters, the list of suitable settlements will be narrowed down gradually.

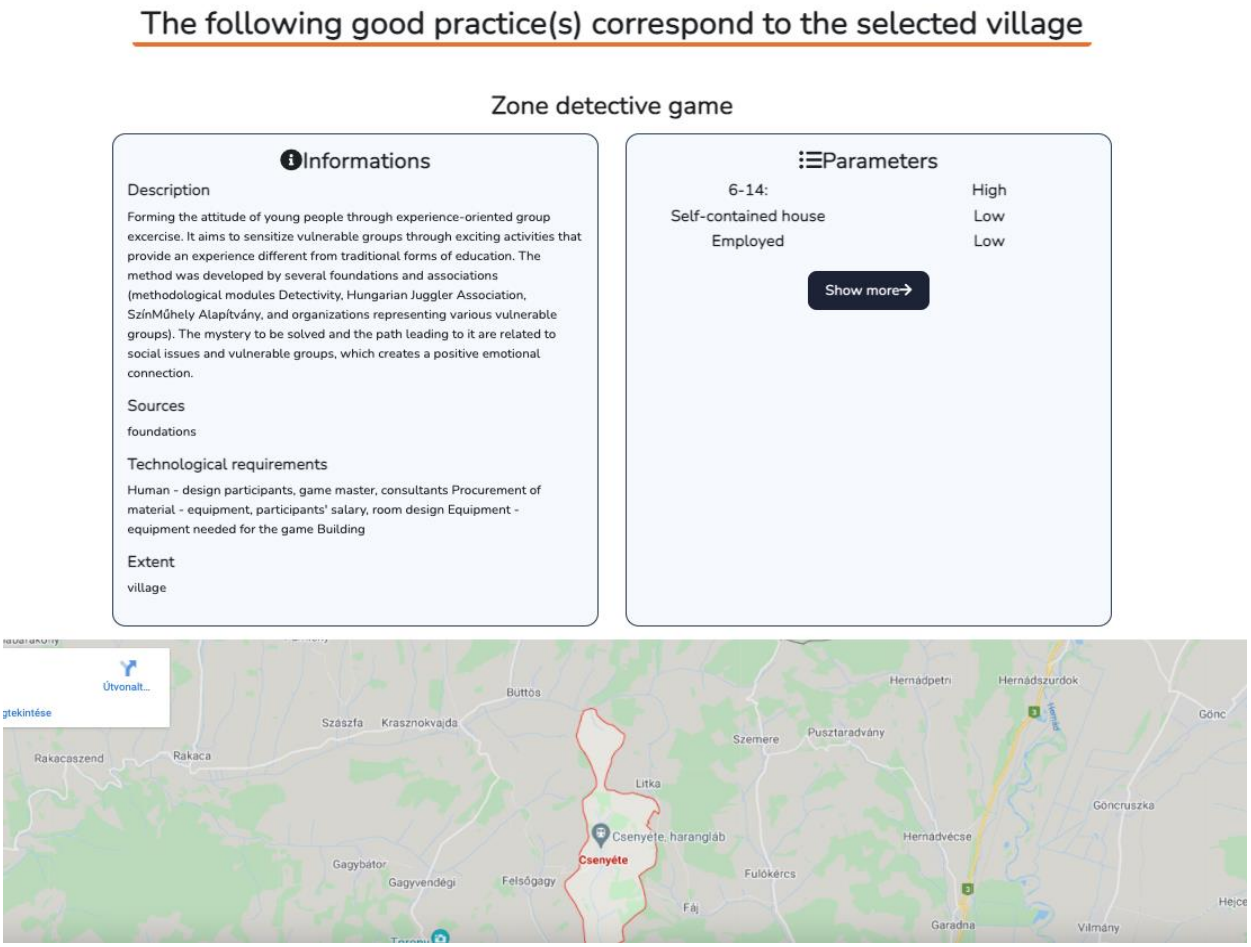

Figure 3. *Good practices filtered for a village.*
Source: own editing

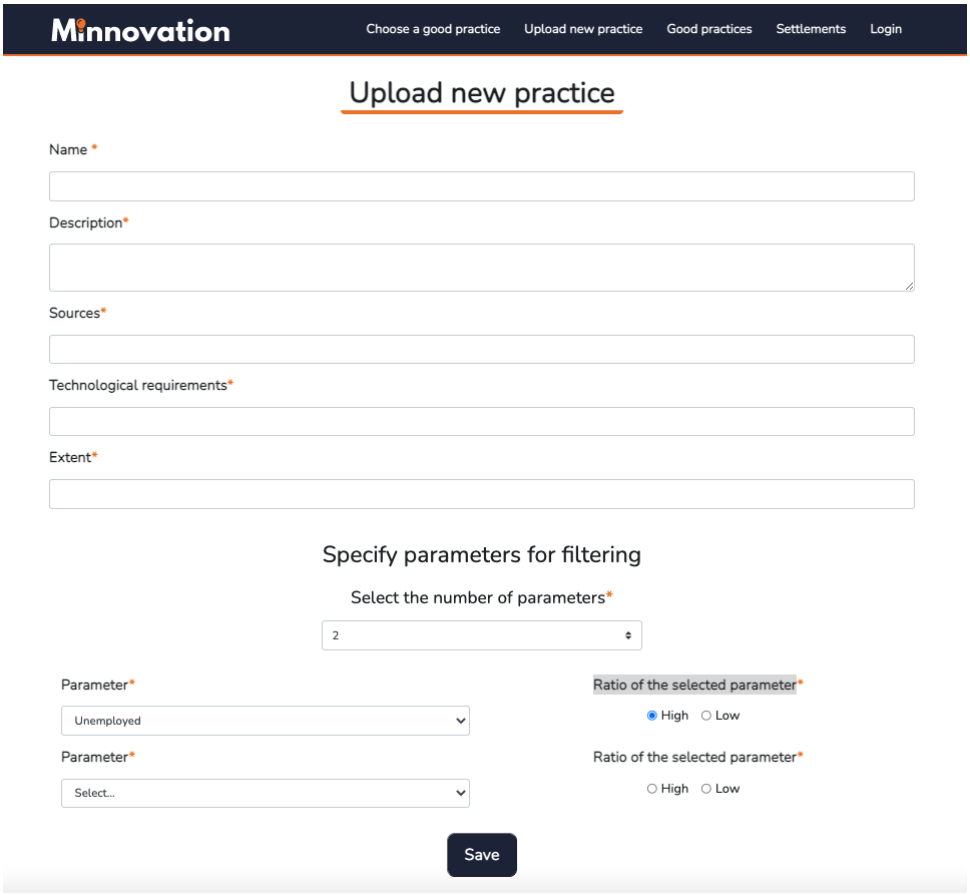

Figure 4. *Upload new practice.*
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5. Summary

The research discussed social innovation and presented good practices. We presented a web application based on the model presented in (Házy-Veres et al., 2020) that offers alternatives for a given region. Our goal was to create a web application which examines whether a particular good practice can be applied in a settlement or what good practices can be developed in a given settlement or vice versa, list suitable settlements based on the knowledge of a good practice.

The knowledge base of the application contains a wealth of data on the various settlements. The collection of this data can be expanded, and it also provides the opportunity to categorise settlements based on the available data. For example, this data can be used to categorise settlements by the age of their population and by the population's education level. The application provides the possibility to manage a wealth of data and to filter it based on various criteria.

For the software to work accurately, as much data as possible needs to be uploaded and categorised as precisely as possible, both by settlements and by good practices, so it is important that the database can be easily expanded by the users.

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