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Presenting a Model for Integrated Crisis Management in Smart Cities from the Viewpoint of Passive Defense Based on AHP and ANFIS

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ABSTRACT: Currently, the ever-increasing population growth coupled with the people's tendency toward urbanization, especially in developing countries, has led to a number of environmental, economic, social, and security problems, to a point where continuation of the current trends is likely to prevent sustainable urban development. On the other hand, passive defense has gained lots of attention in many countries in the recent past. This is where the concept of smart cities emerges as an ideal solution for tackling the challenges of urbanization. In this research, we began by identifying the most significant factors of integrated crisis management in smart cities with a focus on passive defense, with the importance of each factor further evaluated. The results were then analyzed. In this work, data gathering was performed through a descriptive-analytic method based on library studies. The required qualitative data was collected by library studies by completing a checklist. Subsequently, numerical analyses were conducted using opinions from experts in the passive defense and smart cities studies. Afterward, an analytic hierarchical process (AHP) was utilized to appraise and rank different factors. Next, an adaptive neuro-fuzzy inference system (ANFIS) was coded in MATLAB R2021b, which ended up presenting an integrated model of crisis management in smart cities from the viewpoint of passive defense. Based on the AHP and ANFIS, our findings highlighted the importance of securing the Internet of things (IoT), securing the environment, securing the network, network acceptance control, developing visualization software at the level of operating system (container), suppressing the threats and modification, and the analysis and action-taking when it came to the integrated crisis management in smart cities from the viewpoint of passive defense. Considering the importance of building smart cities, it can be stipulated that comprehensive attention to integrated crisis management in smart cities considering the principles of passive defense can boost urban protection, security, and sustainable development. Therefore, we considered all important factors separately to come up with a final model. The presented model exhibited a final compatibility ratio of 0.059, which is pretty acceptable. Moreover, the trained ANFIS ended up with an RMSE of 0.0179 coupled with an R2 value of 0.9897, indicating the high accuracy of the proposed model.

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1- Introduction

The smart city movement is currently taking place at the national and urban policy levels, leading to hundreds of urban initiatives worldwide that benefit large populations and allocate major resources to themselves. Some of these projects include dimensions beyond technology, necessitating the design of a management model for smart city crisis units from the passive defense perspective. This paper has focused on the measures taken in passive defense since its principles and basics have become increasingly important in all levels, disciplines, occupational, and scientific fields, in addition to operational and military areas. Thus, the current study has used the principles and basics of passive defense to examine and present a management model for the smart city crisis unit based on seven criteria, along with their scoring and weighing. This problem is analyzed using the AHP technique in multi-criteria decision-making. The decision-making criteria were selected and scored by the passive defense and urban planning experts, together with a group of university professors. Then, the Adaptive Neuro-Fuzzy Inference System (ANFIS) was used to analyze the data. The hypotheses discussed in the current research are as follows:

- AHP and ANFIS methods can provide a model based on passive defense while accurately ranking the influential factors on smart city crisis management units.
- Updating and reviewing all influential factors will reduce the smart city vulnerability while facilitating the appropriate and quick response of the crisis management units.

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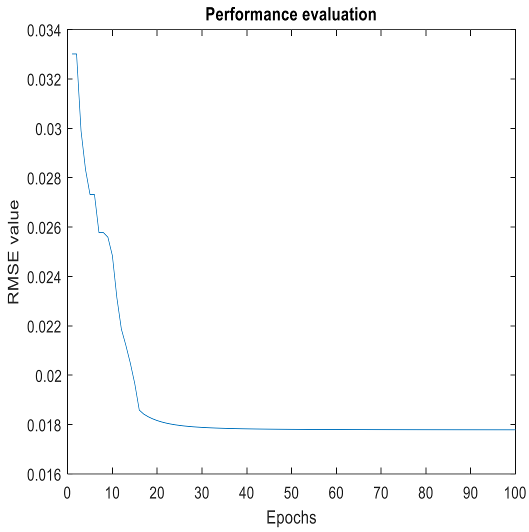

Fig. 1. The performance evaluation process of the proposed model to achieve the lowest RMSE error

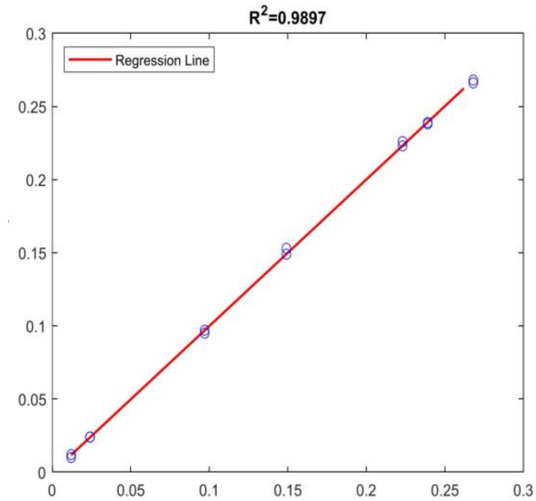

Fig. 2. Scatter diagram of the indicators' final weight

2- Methodology

The introduction should show the background of the subject and main contributions. It is necessary to explain clearly the novelty and contribution of the present work in the last paragraph of the introduction.

2- 1- AHP

AHP is a flexible, robust, and simple method used to make decisions in situations where multiple and conflicting decision criteria make it difficult to choose between alternatives [1].

2- 2- ANFIS

The fuzzy-neural model, developed by Jang in 1993, combines fuzzy logic with artificial neural networks (ANN) to facilitate learning and adaptability [2]. Thus, the main problem in the design of fuzzy systems, which is obtaining the fuzzy 'if-then' rule, is solved by effectively utilizing the ANN capability of automatically generating such rules and optimizing the parameters. ANFIS is an example of a fuzzy-neural model [3].

2- 2- 1- ANFIS Model Architecture

The main point in designing the ANFIS model is to select the Fuzzy Inference System (FIS). For simplicity, the investigated FIS is assumed to consist of two inputs x and y, and one output f, while the rule base includes the 'if-then' rule of the Takagi–Sugeno–Kang (TSK) type. R^2 and Root Mean Squared Error (RMSE) indices were used in this study to check the data accuracy and evaluate the output model with the observed and calculated values. These criteria determine the effectiveness and ability of the model to make valuable predictions [4].

$$R^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(x_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(x_i - \bar{y})^2}} \quad (1)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(x_i - y_i)^2}{n}} \quad (2)$$

In the above relations, x and y indicate the observed and calculated values, respectively, while $\bar{x}$ and $\bar{y}$ are the respective symbols for mean observed and calculated values. The number of data and the total data are also shown by i and n.

3- Results and Discussion

The final consistency ratio was 0.059 in this research, which is acceptable. Also, the RMSE error value of the trained ANFIS network and its R^2 were 0.0179 and 0.9897, indicating significantly high accuracy of the proposed model, as shown in Figures 1 and 2, respectively.

The variables can be drawn in the form of a model after their relationships and levels are determined. Hence, the Internet of Things (IoT) security allocated the first level to itself, followed by other components based on their importance and measures taken.

4- Conclusions

The current study investigated and evaluated smart city crisis management from the passive defense perspective using AHP and ANFIS methods to identify and rank the influential factors. Future studies should focus on the pilot implementation of the smart city crisis management unit using the model presented in this paper to examine one of the cities closer to the smart city concept and assess its resilience against crises. Since implementing smart city projects imposes high costs and complexities, extensive and detailed research will be necessary to prepare a comprehensive plan and develop a technical and business model considering different aspects of the project.

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