

CHAPTER VIII

DISCUSSION AND CONCLUSION

8.1 Introduction

This chapter summarises the work conducted in this research and provides a summary of the contributions and limitations of the architecture and recommendations for future research. This chapter also examines the research objectives and research questions to determine whether they have been met successfully.

8.2 Discussion

In daily life, every individual can face a wide range of events, where most of the activities have a certain degree of threats that can positively or negatively affect lives. Landmine accidents within areas affected by landmines are one of the greatest risks to humans. Therefore, tracking and ERA systems must have a high degree of reliability and efficiency and should anticipate the needs of a user.

Firstly, we discussed the concepts of AI technology, including FL, ANNs, GA and ES. We found that ES offers the advantage of making rational decisions and increasing the expertise of staff. It can also be used as a training aid to increase the expertise of staff.

However, this approach suffers from its incapability to cover a wide range of knowledge.

By contrast, the fuzzy approach has the capability to represent imprecise knowledge in a simple and understandable manner for both users and specialist. Furthermore, it is suitable for uncertain or approximate reasoning, particularly for a system whose mathematical model is difficult to derive. However, FL faces a problem in defining the MF parameters given that no systematic procedure is available to define these parameters. Therefore, the parameters must be predetermined by expert knowledge about the modelled system. In addition, fuzzy systems lack the capability to learn and cannot adjust themselves to a new environment. However, they can explain how they arrive at a particular solution.

GA is generally accepted as the best option for solving a variety of complex problems. It is also used as a problem-solving mechanism that generates multiple results that are the most appropriate. However, GA requires a decent-sized population and numerous generations. Therefore, its process can be extremely slow when it is solving a considerably complex problem with a large number of parameters and it may take long time to obtain good results.

ANNs have the capability to implicitly detect complex nonlinear relationships between dependent and independent variables. It also has the capability to learn from input-output pairs and to adapt to such pairs in an interactive manner. However, ANNs adopt a black box learning approach. It cannot interpret the relationship between input and

output and cannot deal with uncertainties. Moreover, it cannot extrapolate the results. ANNs also have no capability to extract knowledge (weights in ANNs).

The analysis of the previous literature shows that many frameworks have been developed for tracking and ERA. However, most of these systems have focused on using a single AI technique, whereas others have been designed without using AI tools, which affects the effectiveness and efficiency of these frameworks. Furthermore, several frameworks are more complicated than their portable counterparts due to the use of complex hardware. Some previous frameworks lack the capability to learn and cannot adjust to a new environment.

To improve the effectiveness and efficiency of tracking and ERA systems and to overcome the limitations of using individual intelligent techniques in these systems, a new hybrid architecture was proposed by integrating three types of AI technique (ANNs, FL and GA) into two models, namely, NFRAM and the safe path selection model. The proposed hybrid conceptual architecture is described in detail in Chapter V.

NFRAM is based on the FL model and ANNs. This model consists of 3 input variables: signal strength, position and landmine intensity. A total of 20 rules were designed based on the knowledge of domain experts. These rules were used to determine the output parameter value (risk) according to the 3 input values. For MF evaluation, the researcher adopted the triangular membership function method. A neural network was used to fine-tune the knowledge base and MFs of a fuzzy controller whilst keeping the semantics of FIS intact by using the BP algorithm.

To validate NFRAM, the BP algorithm was used to train the model in 4D input–output space. NFRAM was trained using the same training dataset used for FIS (Mamdani and Sugeno models). The output result was compared with NFRAM. Each training pattern was determined by 4 variables: 3 inputs (signal strength, location and landmine intensity) and 1 output (risk).

The comparison of the results of NFRAM with those of the Mamdani and Sugeno models is presented in Chapter VII, Table 7.1. This table summarises the results achieved by the three models over the same dataset. Some terms used in the table for the input parameters are as follows: signal strength, position (m) and landmine intensity (Klm^2). The comparison shows that NFRAM provides better results than the other models. The results derived by NFRAM are accurate, where the ratio of difference among the Mamdani model, Sugeno model and NFRAM is approximately $0\% \cong 10.8\%$.

The role of DSS is to assist decision makers in making strategic decisions by presenting information and interpretations for various alternatives. We have implemented a model called the safe path selection model by using GA. The model aims to aid users in selecting a safe route that he/she can follow to get out of landmine-affected areas without any accident. The model provides directions from the current location of the user to outside the mined area by updating the location of the user and generating a new direction once the previous one has been completed.

To efficiently evaluate the safe path selection model, we introduced two pruning algorithms, i.e. Dijkstra's algorithm and the Floyd–Warshall algorithm. We implemented these algorithms and compared their results with those of the proposed

model. From the simulation, each algorithm was determined to have particular features that eventually lead to differences in their properties and performance. A slight difference was observed among the results, where Dijkstra's algorithm = 150 μ s, the Floyd–Warshall algorithm = 184 μ s and GA (Safe Path Selection Model) = 96 μ s.

Despite its advantages, the ERAA architecture has limitations. For example, the architecture exhibits strong dependence on GPS services and GSM coverage. Hence, failure to receive GSM/GPRS signal stops the architecture. Moreover, the accuracy of the architecture is affected by the accuracy of GPS, which is operated in the USA, where the accuracy of GPS occasionally reaches up to 100 m. Thus, the architecture will be adversely affected by this service. A resource constraint is a limit on what can be achieved because of limitations on the resources available to achieve it. In this context, the architecture faces a problem that is represented by the lack of equipment for mining surveying and the lack of available information about areas affected by landmines.

Table 8.1 presents a comparison between ERAA and previous ERA frameworks in terms of advantages and limitations.

Table 8. 1: Comparison Between ERAA and Previous Tracking and ERA Frameworks

(Author)	Environment	Risk Assessment		DSS	LBC	Advantages	Limitations
		Intelligence Techniques	Tracking Techniques				
ERAA	Landmark	ANNS + GPS	Cellular Network			<ul style="list-style-type: none"> Hybrid Architecture (Three in One) Supports LBS Supports Decision-making Capability to Learn Easy to Use Low Cost Autonomous operation Flexible mobile platforms 	<ul style="list-style-type: none"> Requires GSM coverage Resource constraint Supports only Android platform
Murat et al. (2009)	Tracking services	Null	Null	Null		<ul style="list-style-type: none"> Easy to use Low average cost Flexible mobile platforms Converts low-level cell phone location logs to high-level semantic mobility information 	<ul style="list-style-type: none"> Lacks use of intelligent technology to support decision-making Outdoor use only Incapability to learn

(Author)	Environment	Risk Assessment		DSS	LBC	Advantages	Limitations
		Intelligence Techniques	Tracking Techniques				
Alshbatat (2013)	Landmine	FL	Special Algorithm		IR + Ultrasonic	<ul style="list-style-type: none"> Autonomous operation Supports Decision-making 	<ul style="list-style-type: none"> Too complex and unfriendly interface Incapability to learn Individual intelligence techniques Difficulty of maintenance High
Tayal & Prema (2014a); (2014b)	Tsunami	FL	FL	Null		<ul style="list-style-type: none"> 5 parameters 83 rules More capable Provides better results 	<ul style="list-style-type: none"> Requires high expert knowledge Incapability to learn Individual intelligence techniques Unsupported decision-making

(Author)	Environment	Risk Assessment		DSS	LBC	Advantages	Limitations
		Intelligence Techniques	Tracking Techniques				
Achkar & Owayjan (2012)	Landmine	ANNs	Null	Null	Image Processing Technique	<ul style="list-style-type: none"> • Capability to learn • Autonomous operation 	<ul style="list-style-type: none"> • Large numbers of inputs and outputs • High cost • Too complex • Opaque • Lacks decision-making • Individual intelligence techniques
Wang et al. (2015)	Desertification	FL	Null	Null	Null	<ul style="list-style-type: none"> • 4 parameters • Supports decision-making 	<ul style="list-style-type: none"> • Incapability to learn • Individual intelligence techniques • Requires high expert knowledge
Lakshmi et al. (2015)	Detecting Drowsy Drivers	ANNs	Null	Null	Image Processing Technique	<ul style="list-style-type: none"> • Classification accuracy of 95% • 97% • Capability to learn 	<ul style="list-style-type: none"> • Lack of light • Opaque • Lacks decision-making

(Author)	Environment	Risk Assessment		Advantages	Limitations
		DSS	LBC		
		Intelligence Techniques	Tracking Techniques		
Bekhet & Eletter (2014)	Commercial Banks	ANNs	Null	<ul style="list-style-type: none"> Lower type error than RBF 	<ul style="list-style-type: none"> Black box because extorting any symbolic information from their internal configurations is impossible
Li et al. (2013)	Floods	ANNs	Null	<p>Smoother and more accurate than that obtained using the traditional statistical method</p>	<ul style="list-style-type: none"> A given sample is considered fuzzy due to its small size

8.3 Meeting the Research Objectives

The research objectives mentioned in Chapter I are revisited and discussed as follows, along with the extent to which these objectives have been fulfilled.

- A. To design and develop an optimised environmental risk assessment architecture for landmine tracking and decision-making using ANNs, FL and GA

This objective was achieved in Chapters II, IV and V. To achieve this objective, many activities were conducted and discussed in this thesis.

Several intelligent technologies and approaches, including ES, FL, GA and ANNs, were presented (Section 2.3). The advantages and disadvantages of each technique are summarised in Table 2.2.

Several IDSS systems, such as congestion problems, demining, emergency management (disasters, healthcare institutions) and human navigation, along with their limitations, were summarised in Table 2.3

In Chapter II, we presented several approaches to perform risk analysis. These approaches were classified into two categories: subjective models (i.e. fuzzy set methods) and classical models (i.e. probabilistic methods). Several past studies that addressed risk analysis were also presented. The limitations of each technique were highlighted. A list of previous works on ERA using individual intelligent techniques, with their advantages and disadvantages, was presented in Table 2.4.

In this study, too much emphasis was placed on overcoming the main drawback of using individual intelligence techniques in systems for assessing and tracking environmental risks, as well as on improving effectiveness and efficiency. Thus, a new hybrid architecture was proposed by integrating three AI techniques (ANNs, FL, GA) into two models (NFRAM and the safe path selection model). The proposed hybrid conceptual architecture that was used to achieve the objective of this study was fully described in Chapter V.

B. To implement the proposed architecture in a mobile environment

This objective was achieved in Chapter VI. The prototype of the ERAA application was developed in Chapter VI. The approach for the design and development of the ERAA application follows three steps:

- i. ERAA development platforms
- ii. ERAA user interface design
- iii. ERAA installation

The development of the ERAA application prototype followed DSRM, which was adopted to develop the ERAA application.

C. To evaluate the performance of the proposed architecture and prototype

This objective was achieved in Chapter VII. In the evaluation stage, two evaluation methods were used: an analytical method and an experimental method. The analytical method was used to validate the neuro-fuzzy architecture for landmine tracking and risk assessment, whereas the experimental method was used to evaluate the ERAA

prototype. The prototype was examined using a heuristic evaluation strategy to determine whether it is suitable for assisting users avoid the risk of landmines.

8.4 Research Limitations

The limitations can be summarised according to geographical, financial and logistic issues as follows.

A. The application has been tested using a local server with only test data due to the lack of equipment for mining surveying and the lack of available information about areas affected by landmines. Thus, this app needs to be tested using real data.

B. Several studies have asserted that developing mobile application pages are more complicated than developing pages for a standard web browser due to the limitations of mobile devices, such as the restrictions on the size of the screen space and internal memory.

C. In terms of size, Libya ranks 4th among countries in Africa and 17th among countries in the world. Its vast area cannot be fully covered by communication networks. Consequently, the majority of mine-affected areas are outside the range of wireless network coverage. The ERAA application relies entirely on signal strength and the location of the user; therefore, failure to receive signal causes the system to stop.

D. The ERAA application was developed using Java language. Thus, this application can be run only on mobile phones that support the Android platform.

8.5 Contributions of the Study

This study intends to propose solutions that contribute generally to improving the quality of ERA systems and enhancing the performance of these systems. The specific contributions of this study can be categorised into theoretical, functional and practical.

8.5.1 Practical Contributions

A. Environmental Risk Assessment Architecture

Risk prediction is considered one of the crucial steps in any risk management framework. Reliance on individual qualitative techniques in ERA, such as FL and neural network, leads to the lack of capability to provide an accurate estimate of risk events. Thus, the adoption of individual intelligent technology creates more need to establish more hybrid intelligent systems, which combines at least two intelligent technologies, to achieve the requirements posed by ERA systems. A hybrid intelligent system is a combination of methods and techniques from AI.

This study proposes ERAA, which provides the possibility of combining three well-known techniques, namely, ANNs, FL and GAs in one coherent environment. The proposed architecture is implemented in the form of two models (NFRAM and the safe path selection model).

i. Neuro-Fuzzy Risk Assessment Model

This model was developed through several stages. In the first stage, the Sugeno fuzzy method was developed using the primary FIS. In the second stage, a neural network was used to fine-tune the knowledge base and MFs of a fuzzy controller whilst keeping the semantics of FIS intact using the BP algorithm. The approach was designed, implemented and successfully evaluated on a benchmark dataset, which showed improved accuracy in risk classification compared with other fuzzy models. The level of risks was classified as points between 0 and 100, which indicated the levels of danger that the user is facing near areas affected by landmines. Finally, NFRAM was trained using the BP algorithm in the last stage. The methodology used for developing the model was presented in Chapters III and V.

ii. Safe Path Selection Model

A good decision during emergency situations is crucial given that an early and accurate decision can reduce the loss of people's lives. The safe path selection model is considered the most important component of the hybrid architecture. It was developed with GA that could be used to support decision-making. The objective of this model is to assist users in making decisions during emergency situations (inside mined areas). It provides users with tips on how to spot minefields and how to avoid them if he/she enters a minefield. It also provides directions (safe roads) to the user from his/her current location to outside the mined area by updating the location of the user and generating a new direction once the previous one has been completed.

In this context, GA was used to encode a path in a graph into a chromosome. The methodology used to develop the safe path selection model was identified as presented in Chapters III and V.

iii. Prototype of the ERAA System

The prototype of the ERAA application was successfully developed. The Java language was used to create all the components of the ERAA application. The Microsoft SQL Server 2008 database was used for database hosting on the server site with Google Maps embedded.

8.5.2 Theoretical and Functional Contributions

- A. Different AI tools are introduced, including ES, FL, GA and ANNs. The advantages and disadvantages of each technique was summarised.
- B. Existing DSS and AI that were used in tracking and environmental DSS are also presented.
- C. Different methods on risk assessment and risk analysis are presented. Previous studies that address risk analysis are also reviewed. The advantages and disadvantages of each technique are summarised.

8.6 Future Works

Future extensions can be summarised in the following points.

A. This study focused on Libyan citizens to help them avoid the risk of landmines. To receive more benefits from this study, it can be expanded to include all countries affected by landmines.

B. Although the ERAA application was applied to the problems of humanitarian demining, it has wider potential and can be applied to other crisis situations, such as estimating risk-associated areas contaminated by nuclear radiation, endemic areas of communicable diseases and areas of natural disasters, such as floods and landslides.

C. A new version of the ERAA application for mobile phones that use IOS (originally iPhone OS) as a platform can be provided.

8.7 Conclusion

This study has looked into the possibility of strengthening tracking and environmental risk systems that depend on individual intelligence technologies. It intends to overcome the limitations of such techniques, and thus, enhance the performance of such systems by combining three well-known reliability engineering techniques: neural networks, FL and GAs.

This research has produced and proposed ERAA that consists of two main models (NFRAM and the safe path selection model), including various theories and approaches, such as tracking techniques, positioning strategies, LBS architecture, AI techniques and IDSS for ERA.

The proposed architecture presents many aspects that should be considered to develop good applications for tracking and ERA systems. Although considerable work remains in the future, this thesis demonstrates the applicability of a systematic approach using a neuro-fuzzy model to improve the development of tracking and ERA systems.

The findings of this study indicate that the proposed ERAA is also applicable to other developers and can be adopted in their application process, thereby providing their product with a good application for tracking and ERA.

In conclusion, the researcher hopes that the results of this study will be used by developers and will be considered to develop good applications for tracking and ERA systems.

