

CHAPTER IV

CHARACTERISTICS OF ENVIRONMENTAL RISK ASSESSMENT ARCHITECTURE

4.1 Introduction

Mobile applications and their desktop counterparts have numerous differences, and each platform has its own characteristics. To create a successful mobile application, the key characteristics of mobile applications should be understood. The first question in the mind of any developer while creating a software product is: 'what are the qualities of good software?' A successful application should meet all the requirements of the customer or the end-user, and the development stages should be completed within the specified time frame. Furthermore, the costs of developing and maintaining the software should be low.

The characteristics of ERAA discussed in this section provide a picture of what comprises mobile computing and how it can be used effectively to avoid the risk of landmines. All the characteristics mentioned earlier cannot be integrated into a single mobile application because of possible complexities in the output and limitations in cost and errors.

4.2 The Main Characteristics of Environmental Risk Assessment Architecture

4.2.1 Hybrid Architecture (Three in One)

Each intelligence technique has its advantages and disadvantages. For example, FL is suitable for uncertain or approximate reasoning, particularly for a system whose mathematical model is difficult to derive. FL can also represent imprecise knowledge in a simple and understandable manner for both users and specialists. However, FL lacks the capability to learn and cannot adjust to a new environment. The GA technique can be used as a traditional nonlinear solution that cannot always obtain an optimal solution. It is also used as a problem-solving mechanism that can generate the most appropriate multiple results. Furthermore, GA can optimize a variety of problems, such as the travelling salesman problem, which can be eventually linked to circuit design, scheduling and delivery problems. However, GA requires a decent-sized population and numerous generations. Consequently, the GA process can be extremely slow when solving complex problems with a large number of parameters and obtaining good results may take a long time. ANNs exhibit interesting properties that make this family of machine learning algorithms highly appealing when dealing with difficult discovery tasks. However, ANNs adopt a black box learning approach, and thus, they cannot interpret the relationship between input and output and cannot deal with uncertainties.

Several related tracking and ERA systems have been presented in Chapter II. Most of these systems adopt individual intelligence techniques. Thus, the lack of integration among artificial intelligence techniques whilst developing these systems has affected

their efficiency and effectiveness. To overcome the limitations of individual techniques and to enhance performance, three artificial intelligence techniques are adopted to develop the ERAA system. GA and the traditional DSS are integrated to implement the safe selection model, which aims to provide directions for a user. Meanwhile, FL and ANNs are used to develop the risk assessment model.

4.2.2 Supporting Location Based Services

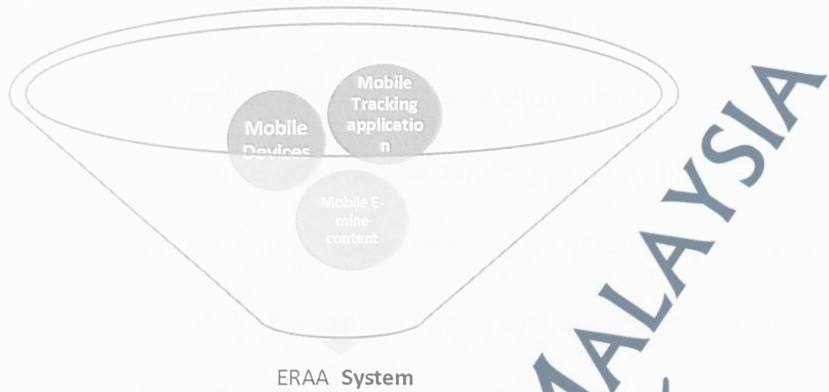
The combination of wireless communication, the Internet, GIS, location-finding techniques and mobile devices has hastened the emergence of a new and dynamic field called LBS, which is currently one of the fastest growing sectors in the cell phone industry.

As mentioned in Chapter II, ERAA has the same characteristics as LBS. ERAA is partitioned into three components, namely, mobile devices, mobile tracking software and mobile e-mine content, with different functions that include positioning, providing maps, and communication. The interactions among these components are illustrated in Figure 4.1.

A. Mobile tracking application

A mobile tracking application is developed using Android SDK, which is open source software that allows any person to develop his/her own application (Android, 2012). A mobile tracking application is designed to be used on mobile devices to protect users anytime and anywhere.

Figure 4. 1 : Components for ERAA



B. Mobile e-mine content

i. Educational content

Mine risk education (MRE) aims to make people aware of threats, and thus, reduce the number of victims. Educating and mobilizing local populations through a variety of information, along with developing teaching materials, training courses and specific activities, are among the factors that can reduce the number of victims.

ii. Geographic Information

Obtaining location information can save lives and reduce risks to individuals. The standards of the Open Geospatial Consortium (OGC) play a key role in such cases. The OGC standards aim to reduce the time required to find, analyse and update crucial information. Most mobile applications implement OGC standards to make indoor and

outdoor location information usable and useful. Thus, OGC can be used to deliver location services, such as wayfinding.

Geographic information includes all relevant information about areas affected by landmines, such as maps, field records and witness reports after they have been digitised and saved into a database. This information was obtained from the Libyan Mine Action Centre, which currently serves as the lead organisation that addresses weapon security according to the Ministry of Defence of Libya.

C. Mobile Devices

Mobile devices include PDAs, tablet PCs, smartphones, cell phones and notebooks, along with their hardware and software features. Smartphones are currently the most widely used electronic devices because they are a part of the daily lives of most people. Smartphones have led the field of mobile applications to become one of the fastest growing segments of the software industry. However, many of these applications are complex and do not always meet user expectations. The ERAA system can work in any smartphone that supports the Android platform, such as Samsung mobile phones.

4.2.3 Supporting Decision-making

People frequently say that making decisions is difficult. Decision-making involves choosing among possible solutions for a problem. Decisions can be made through either an intuitive or reasoned process, or a combination of the two. Decision-making in a dangerous environment, such as a landmine area, is important because the consequences

to making a wrong decision can be fatal. When a user is making a decision on how to spot a minefield, he/she should weigh his/her options carefully because poor choices can result in serious consequences.

Recently, the inclusion of AI techniques, such as knowledge bases, neural networks, GAs, natural language, multi-agent systems and FL, has led to many improvements in the DSS field, which is considered an effort to develop computer-based systems that mimic human qualities, such as approximation, reasoning, intuition and plain common sense. Consequently, a new common denomination has emerged, i.e. IDSS.

IDSS is an integration of AI techniques and computer-based systems that use data, expert knowledge and models to support decision makers. AI techniques, computer-based systems and human knowledge are the three components required to develop IDSS, which can help decision makers during different phases of decision-making.

The ERAA system integrates traditional DSS with AI techniques (GA). GA is considered one of the most widely used intelligence techniques and has been proven to work for selection decision.

A decision support engine is used to assist decision makers in making strategic decisions by presenting information and interpretations for various alternatives. A model called the safe path selection model, which is implemented using GAs, aims to provide directions from the current location of a user to outside a mined area by updating the location of the user and generating a new track once the previous direction has been completed.

4.2.4 Intelligence and Capability to Learn

ANNs are considered a new AI method that is used in learning from data. ANNs consists of a set of one or more neurons, which are the basic processing elements and different sections of layers (the middle layers are typically called hidden layers). A neuron consists of multiple inputs and a single output. Each input is modified by a weight, which multiplies with the input value. The power of neural networks originates from nerve cells that communicate with one another on a grid. ANNs have advantages that make this family of machine learning algorithms extremely appealing when dealing with difficult discovery tasks. For example, ANNs can implicitly detect complex nonlinear relationships between dependent and independent variables. Moreover, ANNs have the capability to learn from input and output pairs and to adapt to such pairs in an interactive manner.

ANNs and FL are used to implement NFRAM. As mentioned in the problem statement, fuzzy systems face the problem of defining MF parameters because no systematic procedure for defining such parameters is available. Consequently, fuzzy systems lack the capability to adjust to a new environment. The objective of using ANNs is to find a solution for the error caused by the poor selection of membership. Neural network learning techniques are used to tune MFs using an FIS controller whilst keeping the semantics of FIS intact.

The ERAA system can learn from input and output pairs and adapt to such pairs in an interactive manner through NFRAM. ANNs have been used to train this model to reduce errors caused by the difference between the simulation outputs and the desired

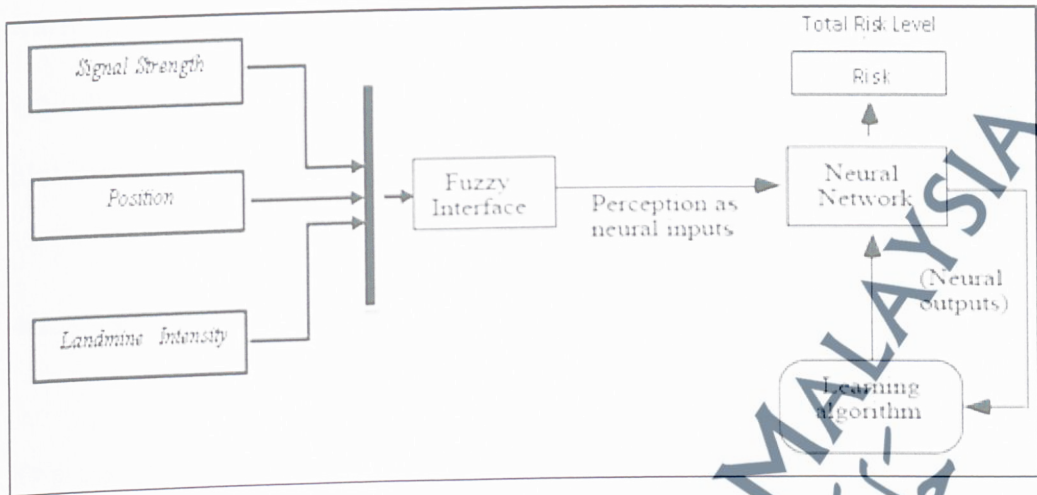
outputs. The BP algorithm is used to generate the adjustments of the input and output MFs and reduce the rules that tend to take control away from the desired path. The mechanism of the BP algorithm is presented by calculating system output and comparing it with the desired output of the training sample. Then, the error (i.e., the difference) is propagated backwards through the network from the output layer to the input layer.

4.2.5 Supporting Landmine Risk Assessments

Although FL and ANNs have been used successfully in many applications to support risk assessment in emergency operations, the integration of AI techniques in developing such systems remains minimal, thereby affecting the efficiency and effectiveness of these systems.

The ERAA system uses NFRAM, which aims to determine the degree of danger faced by a user near an area affected by landmines. The modelling technique was designed according to the concept of FL in the form of IF-THEN rules, which offer a convenient means of representing the relationships between the inputs and outputs of a risk assessment system and ANNs to tune MFs whilst keeping the semantics of FIS intact. NFRAM uses 3 input variables: signal quality, position and landmine intensity. By contrast, the output parameter values (low risk, moderate risk and high risk) are determined using 20 rules according to the 3 input values, as shown in Figure (4.2).

Figure 4. 2: Structure of the neuro-fuzzy risk assessment model



4.2.6 Low Cost

Many countries worldwide suffer from the problem of landmines. However, no official report has yet been made to detect the number of mines planted in the world. Flexible, modular, reliable, low-cost and fast solutions are necessary to increase the safety of users. Landmines have specific properties that make them difficult to detect. These properties make landmine detectors complex. Many examples that address the increasing complexity of landmine detection can be found in the literature. However, these techniques are high cost and require experts to operate.

Several developing countries face financial difficulties in obtaining advanced technologies, such as robotic systems, for detecting landmines because of the high cost and usage and maintenance difficulties of such systems, which make them unaffordable for these countries. The safety of operators, and the transportability, ease of maintenance and operation of equipment are the most important factors that must be considered to improve the applicability and effectiveness of landmine tracking systems.

The ERAA system uses smartphones instead of complex hardware to provide alerts and warnings, thereby reducing complexity and enhancing ease of operation. The ERAA system is easy to use, easy to understand, has low average cost and uses flexible mobile platforms due to the use of smartphones.

4.2.7 Functional Approach

The essential purpose of any product or service is functionality, which can be defined as the totality of essential functions provided by a software product. Functions are considered the main pillars of a system. Functionality is 'a set of attributes that bear on the existence of a set of functions and their specified properties. The functions are those that satisfy stated or implied needs.' Functionality consists of five sub-factors: suitability, accuracy, interoperability, compliance and security.

ERAA uses the inherent functionalities of smartphones, such as the compass, GPS and Wi-Fi. ERAA comprises several components that provide specific functionality, which can be divided into the following sub-characteristics and attributes: (A) Activity Functions provided by the system, (B) Service Functions aim to perform background processing (C) Content providers use to provide data storage and retrieval facilities.

A. Activity Functions

The main functions provided to the user are explained in next section.

i. User Registration

A user should have a username and a password to access the system. If a person does not have an account, then he/she should create one. This function enables a person to access the services of the system by entering a username and a password, which will be sent to the server.

ii. User Log-in

This function allows a user to access the system by entering his/her username and password. Thereafter, the server will receive this information and decide whether permission should be granted to the user to access the service.

iii. Landmine Tracking

Tracking children is a difficult task, and the increasing prevalence of children wandering is a considerable challenge that parents face every day. Keeping constant watch over one's children is difficult; therefore, this function enables parents to track their children by simply using this app. Parents can receive an alert or an SMS on their smartphones from their children's phone if their children approach a minefield. Furthermore, parents can use web-based maps with this app to monitor their children's movement in real time. Through this function, parents can ensure that their children are not wandering near a minefield after school when he/she should be home. Moreover, this function provides a feature that allows a user to track himself/herself. Once a user

moves, he/she will see his/her exact location on a map in real time. This function alerts the user in case he/she approaches a minefield.

iv. Log-out

This function prompts a user to end his/her session by simply clicking on the log-out option, which will take him/her to the log-out screen, where he/she has the option to confirm his/her intent to log out or change his/her mind and return to his/her last ERAA area.

B. Service Functions

Major platforms are equipped with a set of routines, protocols and tools for building software applications, called API, which allows access to many core services of a smartphone. The services provided by a smartphone, including IP connection, phone calling and text messaging, address book and calendar data, microphone, camera, phone location and accelerometer data, can be controlled by API. However, unrestricted access to these capabilities will cause concern among users. The basic functions provided by the ERAA app are as follows.

i. Network unavailability

One of the important functions of the ERAA app is checking the state of the GSM signal. Failure to connect to a network will cause the app to stop working and pose a threat to the life of the user. Therefore, the IWES system regularly monitors the

dynamics of the strength level change of the GSM signal to avoid the aforementioned risk. Appendix (2) presents the function that is used to check the state of network signal.

ii. Lack of GPS Signal

GPS is the most popular satellite navigation system and is widely used for determining outdoor position to find the location and position of an object. This technology is currently implemented in many mobile devices. The latest cell phones and pocket PCs are equipped with GPS capability. GPS is a free service. It is available everywhere, except in a concrete bunker or underwater. This feature enables cell phone users to find the right places, and the exact location of a company vehicle, a missing child or a lost cell phone. ERAA uses two GPS methods to detect user position: GPS satellite and network-based positioning technologies. ERAA has a function that can be used to check the GPS signal. The ERAA system regularly monitors the dynamics of the strength level change of the GPS signal by using the function shown in Appendix (3).

iii. Positioning Function

ERAA uses two methods to find the location and position of a user, namely, positioning through satellite and network-based positioning technologies. Appendix (4) presents the function that is used by the ERAA app to locate user position. Appendix (5) presents the function that is used to calculate the distance between two locations, i.e. A (LongA, LatA) and B (LongB, LatB).

C. Content providers

This function provides direct connection to a MySQL database from ERAA using a JDBC driver that is exclusive for the Android platform. The function shows how the JDBC driver is used in ERAA, as presented in Appendix (6).

4.2.8 Usability (Application Interaction)

Usability is defined as 'a set of attributes that bear on the effort needed for the use of a product or service, based on the individual assessment of such use by a stated or implied set of users' (ISO, 2001). The most important aspect of the design process is to make a user feel comfortable in terms of gadget interaction and sufficiently smart to accomplish any task with intuitive use, without any tutorial or additional help, by providing him/her with the real usage context. Most smartphones are equipped with a touch screen that provides users with a set of opportunities and constraints. These screens are not only used to view content, but also to interact with content. Given their small dimensions, we occasionally expect content structures to be simple and small. Moreover, given their limited bandwidth and connectivity, mobile devices require their designs to be optimized for loading time, with reduced data requirements. Thus, designers should consider ergonomics, gestures, transitions and mobile-specific interaction patterns.

A. Responsiveness

Responsiveness is critical. In fact, an app that requires a large amount of data to start up and takes too long to load will be avoided by users. Users expect prompt response from

mobile devices after they push a button or do anything physical to it. They will try again if they do not receive an immediate response. Thus, users should immediately receive a notification after executing any action on the device to inform them that the loading process is on. The best acknowledgement can be as follows: the request has been received and is being processed in the background, thereby allowing the application to take another request. Another response can be shown as a wait cursor to let users know that their request is being processed. By contrast, the worst response is to do nothing, and thus, leave users wondering if their action has been registered. On the basis of the preceding discussion, the ERAA app provides many notifications whilst the app is running in the background. These notifications can be in the form of a message, an alert or a warning signal in case a risk is detected.

B. User Interface and Ease of Navigation

Most mobile phones support a touch-screen display that offers a rich environment for navigation applications. The market research company Canals reported that over 15 million of the 38.1 million mobile phones sold during the second quarter of 2009 used a touch screen as their primary interface. The main driver behind the increase in the number of keyboard-equipped phones is the growing interest in social networks, such as Facebook and Twitter, which demand increased typing. Mobile applications significantly differ from their desktop counterparts in several ways. The most critical difference is probably the manner in which people use them. Mobile devices are frequently operated using a single hand or by tapping a small screen with a stylus. Furthermore, people use their fingers to click links and buttons on the screen, which significantly decreases the accuracy of clicks.

Many applications use an expanding menu to access the main navigation, which can push the content further down the screen, thereby making it frustrating and awkward to use. A successful application must not be overly complicated. It should be easy to navigate.

Users interact with the ERAA app through frames. The purpose of frames is to host application content and to show the application functionality that typically allows users to interact with content. ERAA includes a significant improvement in interface to use the application, i.e. the interface is large, clear and easy to read. A user can move forward through the content by using the next and previous buttons, generally by selecting categories, sub-categories and then content, and frequently, by moving forward to new related content.

C. Focused Purpose

A successful app should provide a set of actions that it does efficiently. These actions can be user gestures, such as taps or number of clicks, which must be done rapidly. ERAA enables users to quickly enter data, such as username and password. Furthermore, it enables users to show their locations and those of mine-affected areas on regional maps to obtain directions on how to avoid these areas. ERAA has buttons and lists that can provide additional information about landmines and advices on how to avoid their risk. The ERAA app has been programmed to provide a fair solution for the Libyan people that will allow them to take caution and to watch out for mines as they go about their daily lives.

4.2.9 Characteristics Related to Communication

RF is one of the components of a mobile system that is used to implement communication among its components. RF can take many forms, such as WLAN, cell phones and pagers, GPS, cordless computer peripherals, satellite TV, cordless telephone sets, home entertainment system control boxes, remote controlled garage door openers, two-way radios and baby monitors. Specific applications (called mobile applications) are available for each type of device used to operate some of the aforementioned components.

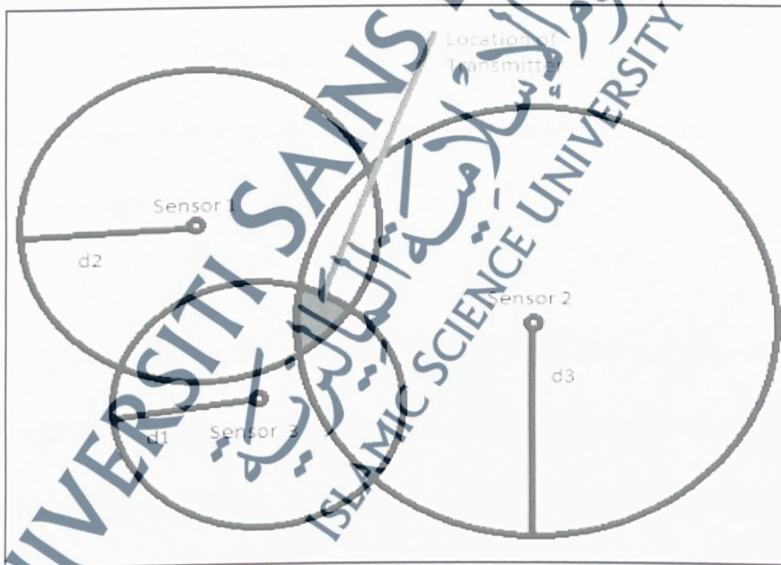
The Cell-ID, also called CGI or COO, is a network-based proximity-positioning method that is frequently used in GSM mobile networks. Locating a mobile phone based on Cell ID is considered the simplest and most common method. However, this method does not provide useful location information for all applications because of the high variability in cell sizes (i.e. from less than 1 km to 20 km).

The concept behind positioning through satellites is to determine the distance between satellites and a receiver device through the messages sent by at least four satellites, which contain information about their exact orbits and the time when the message was sent, apart from other useful information. This information is then processed by the receiver to obtain position and location. GPS is an example of a handset-based positioning system, which is used by a handset to calculate its own position. As mentioned earlier, LAN and GPS are considered the backbone of the ERAA app. This app uses these methods to find the location and position of a user, which can be described as follows.

A. Positioning with TOA

TOA, occasionally called TOF, is the travel time of a radio signal from a single transmitter to a remote single receiver. This method depends on the travel time information (which is equivalent to a range) between the base station and the mobile terminal. TOA uses the points of intersection of circles or spheres whose centres are located at fixed stations. The radii of these circles or spheres are estimated distances to a target to determine the location of the target, as shown in Figure 4.3. For additional details, refer to Chapter III, which discusses the TOA method.

Figure 4.3 : TOA method



B. Positioning with GPS

GPS enables a user to keep track of people and objects that are important to him/her.

ERAA uses GPS and cellular technology to transmit location information to a secure

server that a user can access using his/her computer or smartphone. One of the most important features of ERAA is its update intervals. An update interval is the time that passes between the location updates sent to the server by the ERAA app. To ensure that the location information of a user is receiving accurate and up-to-date data, ERAA will update at least once every 5 min. ERAA allows a user to designate zones on a map. When a user enters or approaches a mine-affected area, the ERAA app will send an alert to the user. Furthermore, it will show the user his/her location and those of mine-affected areas using Google Maps.

4.3 Summary

This chapter presents the characteristics of ERAA, which have been proposed based on the literature review in Chapter II. The architecture is easy to use, supports LBS, supports decision-making, is capable of learning, supports landmine risk assessments and has lower average cost.

The ERAA architecture has all characteristics of DSS and AI. It includes knowledge and data regarding the potential threat of landmines. It can respond quickly, acquire and maintain knowledge regarding a threat and generate new knowledge. The ERAA architecture uses decision rules, models and a comprehensive landmine database, thereby helping users make a good decision that will enable them to avoid the risk of landmines. In addition, the hybrid architecture works autonomously and acts without human intervention.