Improvement Of Mine Detector Using A Quad-Copter, Server, And Smartphone (Ssone)

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ABSTRACT: The main idea of the project is about improving the mines detection methods, maximizing efficient of the detecting operation, and also minimizing cost, time, and effects that occurs as a product of mines. Among of the problems that appear as impacts of buried mines; the first of all is life-threatening, including the civilian people, the military soldiers, the specialists' in the field of the detection, and even the animals walking around the suspected areas. And on the other hand there are several problems occur during attempting of the detection, the most influential problem is represented as the duration of the detection processes, the indiscriminate and unregulated mine's scan operations, and taking into account the unfitness human nature at many sensitive stages of the detection process. By using a mine detector attached at the bottom of an automatic controlled copter supported with a positioning system (GPS) and a communication device to transfer data, receiving the detected mines coordination, and finally uploading the acquired data to a server's database with a and capability of sharing the acquired data with other users., combining all of those are represented a radical solution for the all previously mentioned problems.

1 INTRODUCTION

The field of mine detection is surrounded by many risks and obstacles in both aspects of detection and extraction mines. This paper only focuses about the detection the mine locations and taking into account the whole problems face the field operators, the target people, and innocents' people. The first problem is represented of the duration of the scan operation, fundamentally that problem is forked of two parts, firstly the human's motion is relatively very slow compared to the vehicles and choppers, and another necessary delay is occurred as a precaution of trampling mines. The second target of this paper is to minimizing the cost of detecting mines which appears clearly from the statistics of the UN and other related organizations in the recent. The last disastrous problem is divided into two aspects both of them related with each other, when applying the traditional methods of the detection it should be at least one of them occur, firstly the overlap of the scan which it means scan the same area more than once supposedly it's the first time of the scan due to human nature and the primitive methods of the prospecting, secondly it is very dangerous if it happened, it is ignored an area supposing it has covered, a such fault may cause disaster even this area might be less than $30cm^2$, or less than $10cm^2$ with the anti-personnel mines. Beside of solving the manual detection problems there are many features appear when applying a such system at the level of civilian, and military using the features of the smart phones or manufacturing a specific compatible devices with the system, also the system can be applied at the level of the vehicles by supporting vehicles with auto avoiding system respond for location of the vehicle and mine locations that has stored into an automatically synchronized database with a server, in the other aspect using mines coordinates can make some statistical operation and even to predict the location of the mines in the near or even the long term. Applying the such system protect the operators in the field, the innocent people by using the mobile phones as a mine detector, or even vehicles, also provide scan large area in less possible time with less cost and more efficient at the same time.

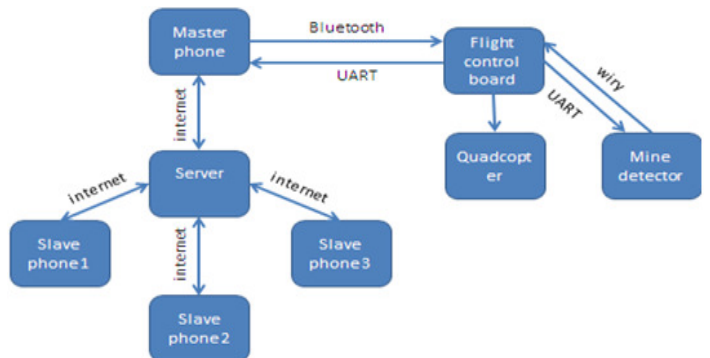## 2 METHODOLOGIES

2.1 Introduction

Figure2.1: *Methodologies Block Diagram*

As it is shown in the figure Figure2.1, the master phone is connected with the flight controller board (FCB) which controls the Quad-copter (QC) using the ESCs, the mines detector is attached at the bottom of the QC and it is connected with FCB in order to register the mines coordination into the FCB's EEPROM when a mine has been detected while the mission, when the mission completes the QC returns back to the predefined coordination, and the master phone will be reconnected again with the FCB in order to fetch data which is stored in the EEPROM during the mission, the acquired data will be uploaded to the server automatically and then it will be shared with the specific devices which is designed for.

2.2 The master phone (App) with FCB

It represents the center al control of the whole system; it initiates the connection with the (QC), monitors and controls the QC, supports the Manual control mode, and prepares details for scan operations. The selected phone is the Android OS mobiles phones to control the system, and there is an App has been developed to be compatible with this system, this Application is developed using Eclipse Software.
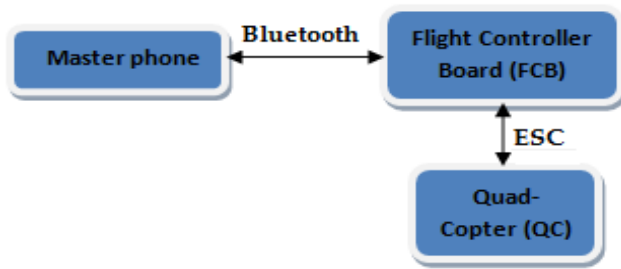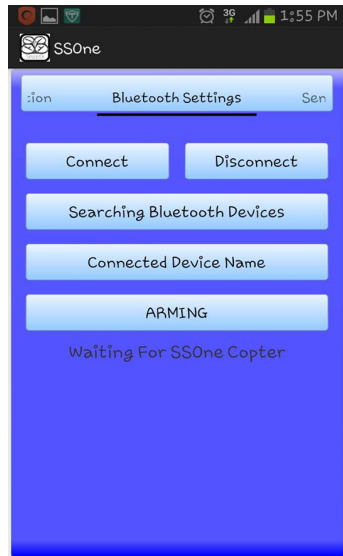
**Figure2.2:** *App with the FCB Block Diagram*

2.2.1 Initiates the connection

The Android platform supports Bluetooth connection, which allows exchanging data with other Bluetooth devices. The application framework provides access to the Bluetooth functionality through the Android Bluetooth APIs connects to other Bluetooth devices. All of the Bluetooth APIs is available in the Android Bluetooth package. As shows the screen shot of the App's Bluetooth GUI. When there is connection channel available between the mobile and the FCB the App will send periodical requests according to the MSP table [11] to the FCB with a time interval of 100ms and then the board responds to the requests by sending back the specific data for each request, these requests and its answers are running into the background. The GUI is used to search the opening Bluetooth devices to make a connection with the paired ones of them, and also it used to reconnect with last connected QC, disconnecting a connected device, and make the QC ready using the ARMING button.

2.2.2 Monitor and Control
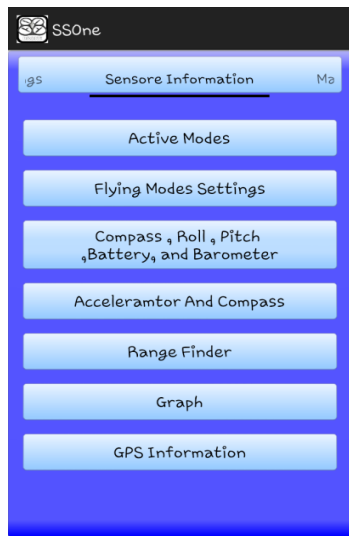
Monitor and control is represented the first challenge of designing the system, the vender who developed the board supports many protocols and which it is called Multiwii Serial Protocols (MSP) (2), this protocols make the board could be connected throughout USB, or wirelessly via a Bluetooth devices to monitor the it's data into a PC-GUI [12], using this protocols there is a GUI has been created, it can send and receive data between the FCB and the App as the same as the communication between the FCB and PC-GUI. as it appears in GUI with many buttons, any of this buttons represents a new GUI when it is pressed, from the top there is Active Mode button is used to indicate the activated flying modes [13], Flying Modes Settings is used to set the level or select the channel which will be used to control, the third button is used to monitor the directions of the QC using the magnetometer sensor, roll and pitch, Battery level, and Barometer sensors. The Accelerator and Gyroscope is used to display the details of the sensors in the three dimensions. The graph button is used to monitor the received signals throughout the receiver coil of the detector head in order to provide a tech-data if needed, also the GUI is used to monitor the details of the connected GPS device.

2.2.3 Manual scanning mode
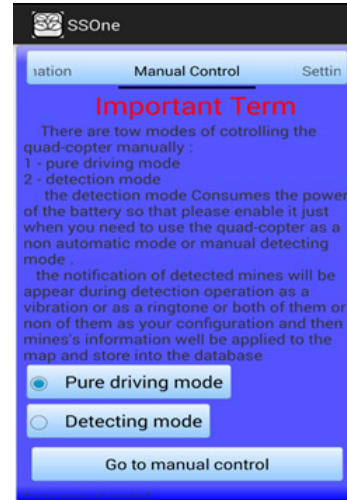
It is the second challenge of the system design, the QCs by default is supported with a specific radio control (RC) device uses to control its flying in the three dimensions, enabling roll, pitch, and yaw movements. So there is an App has been developed with a source code that provide controlling the QCs manually by the same way which the RC follows to control the QCs. Actually This system has been developed with two modes of manual control of the QC such as appears in the selection GUI.

A. Pure driving mode
It is the default mode; it is just used in order to move the QC from one place to another, in this mode the mine detector must be switched off in order to save the power of the battery.

B. Detection mode
It is selected when the operator decided to detect an area manually, in this case the operator must pay attention about the distance between its mobile device and the QC, it should be less than 15meters at maximum, unless that, the connection will be got lost, in this mode the mines data will be sent to the App immediately during the scan mission with a notifications.
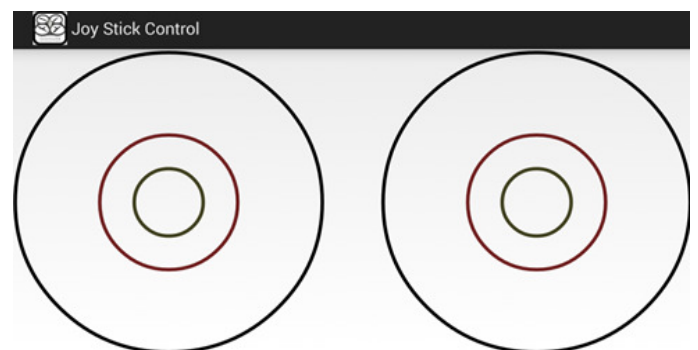

Manual control GUI

2.2.4 Initiate the scan operation
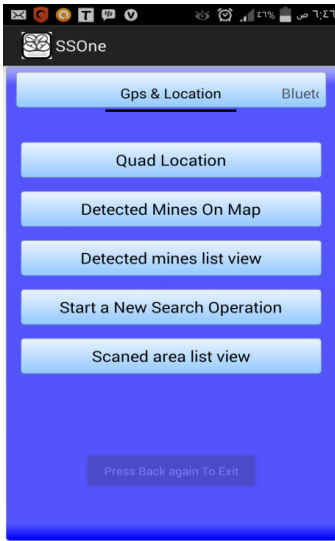
This section represents the development of the manual scanning, utilizing some features of the smart phones, certainly the Google maps, GPS, Bluetooth, GSM, Wi-Fi, and some others. There is an android source code has been developed in order to create a map with specific facilities make it compatibles with the system [14]. The blue GUI is used to determine the current location of the QC into the map according to the sent coordination from the GPS device that connected with the FCB. Also the GUI via Detected mine On Map button is used to display the detected mines into its locations within the map and some facilities such as draw a path from the user's location up to the mine position when the mine is clicked on, also there is an important feature has been developed within the system, the App generates a notifications message to alarm the users when they be within a circular area with a predetermined radius and its center is a mine position, a such feature makes the App acts as a mine detector and also this GUI Acquires data from the QC when finished the missions, puts the data into the phone's database, and finally it synchronizes mines' location into the database with the available server. Also the GUI displays the list of mines and scanned area with deep details for both of them. The start a new Search Operation button is the most important button in the whole App, it consists of many steps, it has been developed throughout many thousands of a complex source code lines, so now to start a new operation the operator must identified a square into the App's map with four corners by clicking directly into the map to determine where the QC should be to scan, and It is noteworthy that the points should be selected consequently and anti-clockwise manner, according to the pressed corners there are many calculations will be occurred in order to inform the operator about the scan's details such as the brown GUI, there are many calculations of the area in order to identify if the battery level wither it will be enough to scan the specified area or not, calculating the distance to start the mission and it depends on the current location of the QC and the location of the starting point, Distance to home also it will be calculated according to the last point of the scan and predetermined home point, the Sum Of line is calculated by the summation of the distance to start, the entire square area, and distance to home, the flying time is calculated depending on the battery level and velocity of QC during the scan and the round trip path. The maximum flying time depends on the full battery level and the actual flying time corresponds to the current battery level, finally there is an evaluation of the operation in order to help the operator to make a right decision about the mission. If alright the operator should press the Test Sensor button to get a report about the sensors status, then press send button to send the area's data to the QC in order to start the mission.

2.2.5 The biggest challenge:
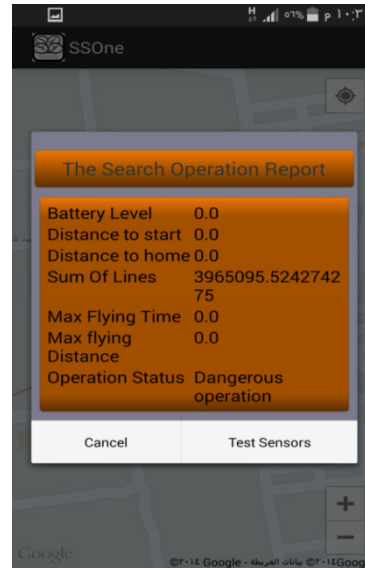
Habitually the QCs come with the RC to control the flying of the QCs, as it had mentioned before, this system has been provided with a simulated RC seam as the actual RC, but this doesn't the ultimate of the system, the system is developed with a source code in order to support a QC with an automatic scan according to the defined square, After many attempts and a much mental effort there is an algorithm has been proofed it could be possible to apply the automatic scan using the QCs. The algorithm has been applied on the App to make an animation and to describe how the scan mission will be occurred such as The *Screen 2.2.5.*
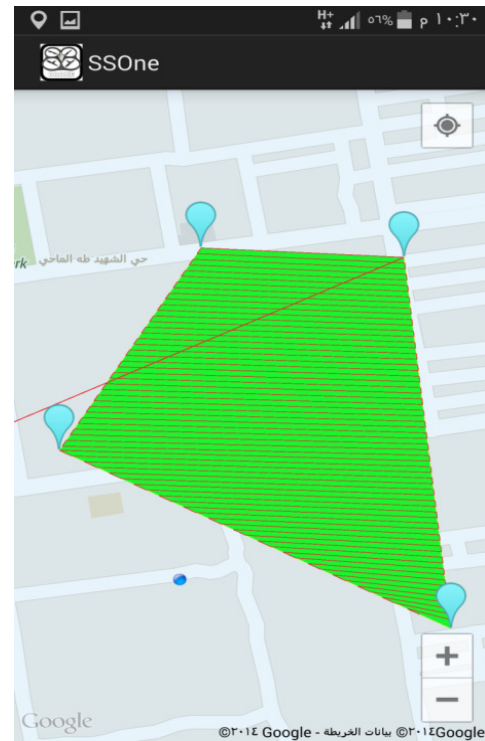
SCREEN 2.2.5.

2.2.6 Conclusion

To initiate the scan operation the operator should start applying four long clicks on the map with anti-clockwise sequence then the App will draw a polygon with corners according to the four points which has been just pressed, then the App will be responded by start animating the scan operation within the square, when the animation is finished the calculations of the determined area will be displayed into the screen, if alright the operator should press the tests sensors button to send a test sensor request to the FCB to report

about the working sensors, in the last if alright the operator presses send button in order to send the polygon's corners coordination to the connected QC to start the mission.

2.3 Quad-Copter with the mine detector

The Figure2.3.a: *the interface between the FCB and the Mine detector*

Actually the QC manufactures for the games purposes, however in order to be fit with this system the built in source code has been redeveloped again to accept the sent coordinates of the corners from the App, then do the same calculations which had calculated within the App's animation and then starts moving cross the path till the end, during its movement the mine detector keeps sending and processing the received signals down to the ground within its range, whenever it detected a mine it immediately will be reported the FCB in order to save the current position coordination into the its EEPROM, at the end of the mission the QC goes ahead to the predefined home point, when the operator reinitiates the connection again and opened The GUI via the Detected mine On map button the data will be fetched automatically from the EEPROM if found such as the Figure3.2.b.
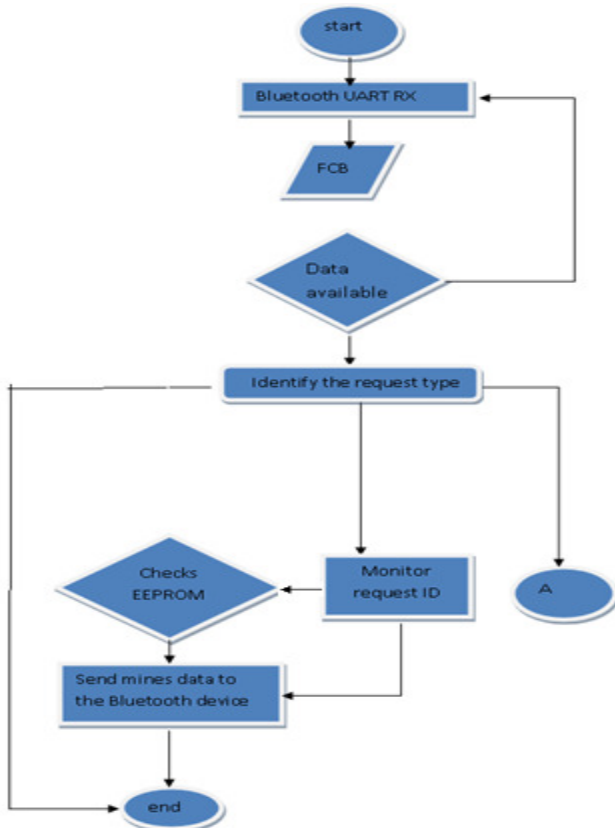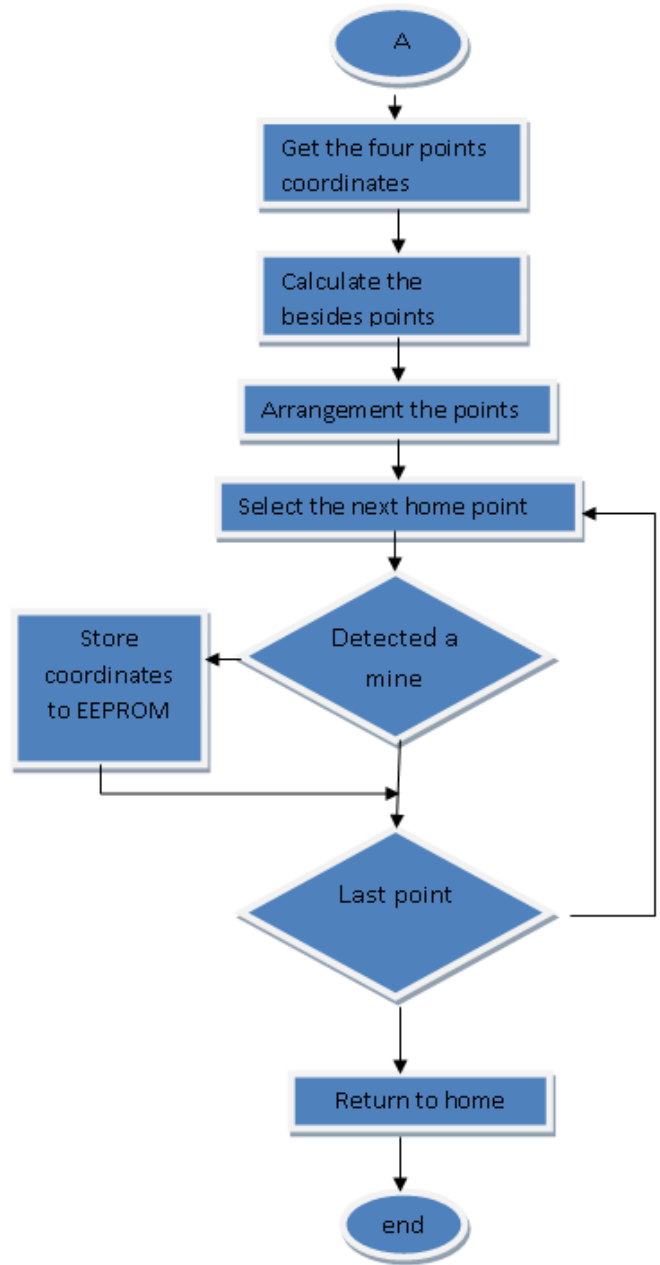

*Figure **3.2.b.***

*Figure **3.2.c.***

2.4 Master and slave's phone with the server

The master mobile phone beside it controls the scan operation also it responsible of uploading the new data to the available, on the other hand the slave's mobiles should be synchronized them database with the server own, and so which means whenever a new data is upload to the server the slaves should have a copy of them. To make that happened there are much processes have been occurred and some source codes developed with many programming languages. In the beginning of designing the server it has been started with a much powerful server is called XAmpp server, it has built in MySQL service with a powerful interface is called phpMyAdmin (6), we used this interface in order to be able to managing the database more easily without using command to handle the database due to its Complexity.
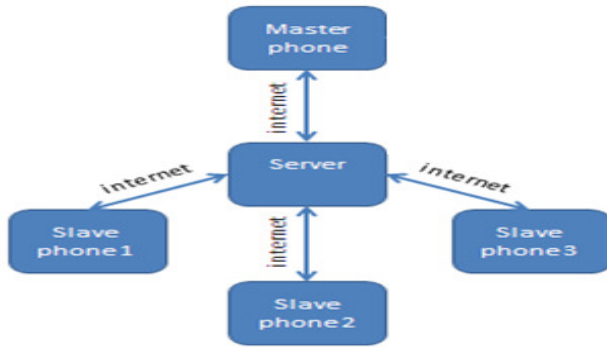
*Figure **2.4***

2.4.1 Database tables
The four tables within the database should access using the mobile in order to save and retrieve data, those tables named Mines_data, Area_coorners, User_info, and Users_comments.

2.4.1.1 Mines_data table
It is the main and more important table in the database that we used to save mines data, this table composes of seven columns firstly the id column which it used to assign a unique numbers for any mine data row, the second column is used to register the time and date when detecting a mine, the third column is used to save some information about the operator who supervised the mission, the fourth and fifth columns is used to save the latitude and longitude where the mine is located in, the sixth column is used to store the types of mines, the last column is used to store the link of the mine data in the web.

2.4.1.2 Area_coorners table
The second most important table in the database, it contains of eleven columns are used to store and retrieve data related with the scanned area. The first column is used for the id number of the rows, the following eight items which is named latitude1, longitude1, latitude2, longitude2, latitude3, longitude3, latitude4, and longitude4 are used to store latitude and longitude of the four corners of detected area, the tenth item used to store the date and time when area was scanned, the last item is used to store some details about the group who supervised the scan area in order to call them back if needed.

2.4.1.3 User_info tables
This is the simplest table in the database, is used only to store user names and passwords of users who can access and benefit from the system, the table is composed of three columns named as id, username, and password.

2.4.1.4 Users_comments table
The last table in the database, the App is also has been supported with a Chatting interface for the operator in order to share comments, so the tables are used to store the users' comments, it is composed of four columns post_id, username, Title and message.

2.4.1.5 Conclusion
Those are the four tables which compose the database, up to now the database is ready to store and retrieve data, so now the question is how to communicate with the database in order to store and retrieve data remotely using mobile phone.

2.4.2 Storing data into database
Beside of building the database with mentioned tables, the second work is how to access database's tables in order to store and retrieve data into the tables, the App and a remote MySQL database cannot communicate with each other directly in an easy way, so there is a need for an interpreter. This interpreter will be PHP. Storing and fetching data from the database follow the same way in the life cycle, there is an android source code has been developed and a simple PHP based web service that to register a new user, login, and parse some JSON data within the App. By using XAmpp server, some PHP source code, and Eclipse software is used to add username and password data into the User_info table, the App is prepared with two fields to enter usernames, and passwords, and a button to submit the registration. When the user fills out this field and hits register button, then the data will be passed to the PHP web service. The web service will be connected to the MySQL database, then find out the User_info table, and finally create a new row with different id number into the table with those information that was sent from the App. Once the row is created, the web service responds with some JSON data to inform the user whether the resister is completed successfully or not. Eventually the App parses this JSON data and display a Success, or a Failure message. The next roll of the table is used to login the registered users in order to then utilize the system features by using another interface is called login GUI, by the same way when the user entered the username and password this data will be sent to the server using PHP, then this data will be compared with the stored usernames and passwords within the table, if this data is matched any table's row the web service display some JSON message say login successfully, unless it will be responded with login failed, if only the login operation is succeeded the App will responds with login successfully and start synchronizing the databases. Uploading mines, areas, and comments data will be followed the same manner to access and store data within the tables.

2.4.3 Retrieve data from the database
In order to download any table contents there is a PHP source code has been developed, by passing the name of table to the PHP web server it will going directly to the identified table and get the entire table's contents in the form of JSON array such as Screen2.4.2.b. The JSON will responds by a message such as Screen2.4.2.c if there is no available data, and then the JSON message can be

```
[
  {
    "id": "1180",
    "date": "Wed, 23 Jul 2014 14:48:41 PM",
    "details": "Sondos",
    "latitude": "38.4564765355014",
    "longitude": "18.28121479600668",
    "magnitude": "MA",
    "link": "www.ssone.com"
  },
  {
    "id": "1182",
    "date": "Wed, 23 Jul 2014 14:51:10 PM",
    "details": "Labeeb",
    "latitude": "9.6224587683914",
    "longitude": "-0.00002212822437286377",
    "magnitude": "MA",
    "link": "www.ssone.com"
  },
  {
    "id": "1184",
    "date": "Wed, 23 Jul 2014 00:56:28 AM",
    "details": "Labeeb",
    "latitude": "-2.343046497523638",
    "longitude": "25.312463454902172",
    "magnitude": "MA",
    "link": "www.ssone.com"
  }
]
```

Screen 2.4.2.b

{"success":0,"message":"No Post Available!"}

Screen 2.4.2.c

Parsed to extract the time and date, latitude, longitude, or whatever data, then this data will be stored in the App's database to be used in application which the system is designed for.

2.4.4 Data synchronization
Transferring data between the App and the server looks as two separate operations, but actually they occur alternately, at once uploading data from the App to the server and at the other downloading data from the server to the App with a time interval can be determined by the user, that which is called the automatic data synchronization, within this system the synchronization occurs by checking the server contents and then the App decides about the operation what it should be:
a) If there is some data within the server doesn't found in the App database, then the App should download this data and put them into its database.
b) If there is some data the within the App's database doesn't exist within the retrieved data from the server then the App should upload this data to the server.

2.4.5 Conclusion
So by using the server, any acquired data from the QC can be uploaded to the server using the master Apps, and then sharing this data with the other slaves Apps, the noteworthy is in the beginning of designing the system both of masters and slaves devices is connected with the server via a local Wi-Fi network, and then the App has been developed to access the server globally using internet and it became an option to the user to select the available access media within its area and even the user selects the IP address of the server if there are more than available ones.

3. RESULT
Applying the system provides many features, in the beginning of all it could be to use the smart phone as a mine detector, make the scan operation easy by using the automatic scan, regard of the time mentioned problem now the duration is became scalable and dependant of the QC velocity, and there is no a danger of trampling a burned mine cause the QC fly above the ground, the cost is reduced very much cause it just is a rechargeable battery and nothing else, and in the last it could be to know the previous detected area precisely .

4. CONCLUSION
It is appeared clearly throughout the system description, there is no any deeply explanation about the mine detector itself; absolutely it doesn't for its indifference, because the detector represents the core of the system and it is the machine which is used to detect the mines which represents the final goal of designing the system, however the system components including master phone, QC, Server, and Slaves phones expecting mine detector combine which is called the multi-task system. it is the system which is used to do many tasks by adding the specific tools and some configurations for each task, regard of this System, it concerns of mines field, so the tool that should be added is a mine detector attaches at the bottom of the copter, .e.g. for the other systems which is related of the metal the tool is a metal detector, for camera monitoring system the tool is a Camera, and so on for spraying fertilizer and pesticide, and even sowing seeds or any other related operations.

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