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Spatio-Temporal Modeling and Application for Efficient Online Reporting and Tracking of Lost Items During Huge Crowd Gatherings

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Abstract: In huge crowd gatherings such as Hajj, the probability of losing personal belongings of the pilgrim is relatively high. The consequences are also severe in some cases for example when someone loses his passport or valuables without which it is difficult to travel back to his country. Therefore, in this paper, we propose modeling and prototype application for effective online reporting and tracking/searching of lost and found items in a huge crowd gathering scenario of Hajj. Hajj is an important pillar of Islam and around 3 million pilgrims visit Makkah and Madinah to perform Hajj. We propose spatio-temporal modeling of all events and data with the context of space and time. We first define spatio-temporal construct of the event and then spatio-temporal functions for effective reporting and tracking of lost items. The modeling aims to facilitate both pilgrims and the lost and found department in Makkah and Madinah. The web-based service will allow pilgrims to report and track the lost and found item online effectively. The proposed model will use the identifying information to match lost items and persons with the found information considering the spatio-temporal context. We present the results of the implementation of web service integrated with spatio-temporal database.

Keywords: Spatio-Temporal Modeling, Huge Crowd gatherings, Hajj and Umrah, Assistance of Pilgrims, Efficient Tracking Of Lost Items.

1. INTRODUCTION

This paper aims to propose the assistance of people in huge gatherings in terms of efficient reporting and tracking of lost items. We consider the scenario of Hajj where around 3 million Muslim pilgrims gather in the city of Makkah and Madinah in Saudi Arabia. With certain modifications, the proposed modeling in this paper can be applied to other huge crowd gathering scenarios. Most of the pilgrims do not know, how to report their missing items and missing persons because of a lack of awareness and knowledge. Currently, no online system for reporting and tracking is available for pilgrims visiting mosques in Makkah and Madinah. Due to the huge crowd elderly and children get separated from their relatives while performing rituals. There are lost and found department in both Masjid-e-Nabvi and Masjid Al-Haram. However, due to a lack of awareness and language barriers, most pilgrims find difficulties to communicate. Currently, there is no way pilgrims can report missing persons or items online. In most cases, these events divert pilgrims from performing religious rituals and consume their time in reporting missing persons and items. To investigate this issue, we have officially established collaboration with the Department of Lost and Found in Masjid-e-Nabvi through proper channel.

We have several meetings with the department of lost and found in Masjid-e-Nabvi to understand the existing system standard procedures. We have also gathered the data from a sample of fifty pilgrims in Masjid-e-Nabvi Madinah through a simple questionnaire to identify real issues faced by pilgrims. As a result of the survey, we found that majority of pilgrims do not know about the department of lost and found in both mosques. Therefore, in this paper**,** we propose spatio-temporal modeling and prototype application for effective online reporting and tracking of lost and found items during Hajj**.** We propose spatio-temporal modeling of all events and data with the context of space and time.

The rest of the papers are described as follows. We briefly describe the existing system of lost and found

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department of Masjid-e-Nabvi Madinah in section 2. Section 3 presents the review of related work with gap analysis. Then, in section 4, we present our proposed spatio-temporal modeling of online reporting and tracking of lost items including spatio-temporal construct, functions, a sketch for automatic spatio-temporal feature logging and initial implementation. Finally, in section 5, we present our conclusion and future directions.

2. EXISTING SYSTEM

There is a department of lost and found in both mosques in Makkah and Madinah. The department follows a traditionally manual process see "Fig. 1", where a visitor or pilgrim has to go to the office and report there and wait for a period of time outside. Normally pilgrims have to wait in long queues to report their missing items or belongings. Most of the pilgrims are non-Arabic speakers and they face difficulties in communicating with the staff in these offices. Therefore, we believe an online portal will not only save their time but also enable pilgrims to provide details information online about the event including time, the location where items are lost for efficient tracking.

3. RELATED WORK

In this section, we present related work in terms of lost and found items in huge crowd gatherings for religious activities. We also review the proposal of locating lost items in some scenarios other than huge crowd gatherings. In [2], authors present CrowdFound, a mobile crowdsourcing system to find lost items. CrowdFound allows users to input lost item descriptions on a map and then sends notifications to users passing near tagged areas [2]. A website captioned 'expatriates' [3] allows to advertise and search for advertises posted related to lost and found in Saudi Arabia including Makkah and Madinah but specifically for huge crowd gathering in Hajj. In [4] the author introduced an integrated recognition system for identifying missing and found objects as well as missing, dead, and found people during Hajj and Umrah. According to [5], it is assumed that the total estimated number of pilgrims will reach 20 million during the third decade of this century. The ultimate goal of this system is to integrate facial recognition and object identification solutions into the Hajj and Umrah rituals. Liu et al., presented 'MissingFound', an assistant system for finding missing companions via mobile crowdsourcing [7]. Authors in [8] used a participatory design study real-time location system based on context mapping using two nursing homes to monitor the assets.

Outside view of Lost and Found Office

Inside view of Lost and Found Office

Figure 1. Current system - Lost and Found Office in Masjid Al Haram, Makkah [1]

In [9], the authors proposed a framework for tracking Hajj pilgrims in a crowded pervasive environment using a system called HajjLocator. In another example, the author in [10] has proposed spatio-temporal modeling for the assistance and tracking of pilgrims in a huge crowd during the Hajj. Similarly, there are papers in the literature such as [13] that propose assistance during prayers for deaf and blind persons using tactile motion sensors.

Now we review literature that proposes a solution for the problem of locating lost items or belonging in scenarios other than pilgrims. For example, authors in [11] propose a hybrid Key Item Locating Method to Assist Elderly Daily Life Using the Internet of Things. As the nearest system has been proposed in [4] and [2]. There is a need for using spatial and temporal cues to be integrated with such applications to be able to accurately match missing persons or items as discussed in [6]. Therefore, in this paper, we propose spatio-temporal modeling and application for reporting and tracking missing items and persons.

4. PROPOSED MODEL OF THE SYSTEM

We now present our proposed spatio-temporal modeling for efficient online reporting and tracking of lost and found items in Masjid-e-Nabvi, which mainly involve three phases as shown in "Fig. 2".

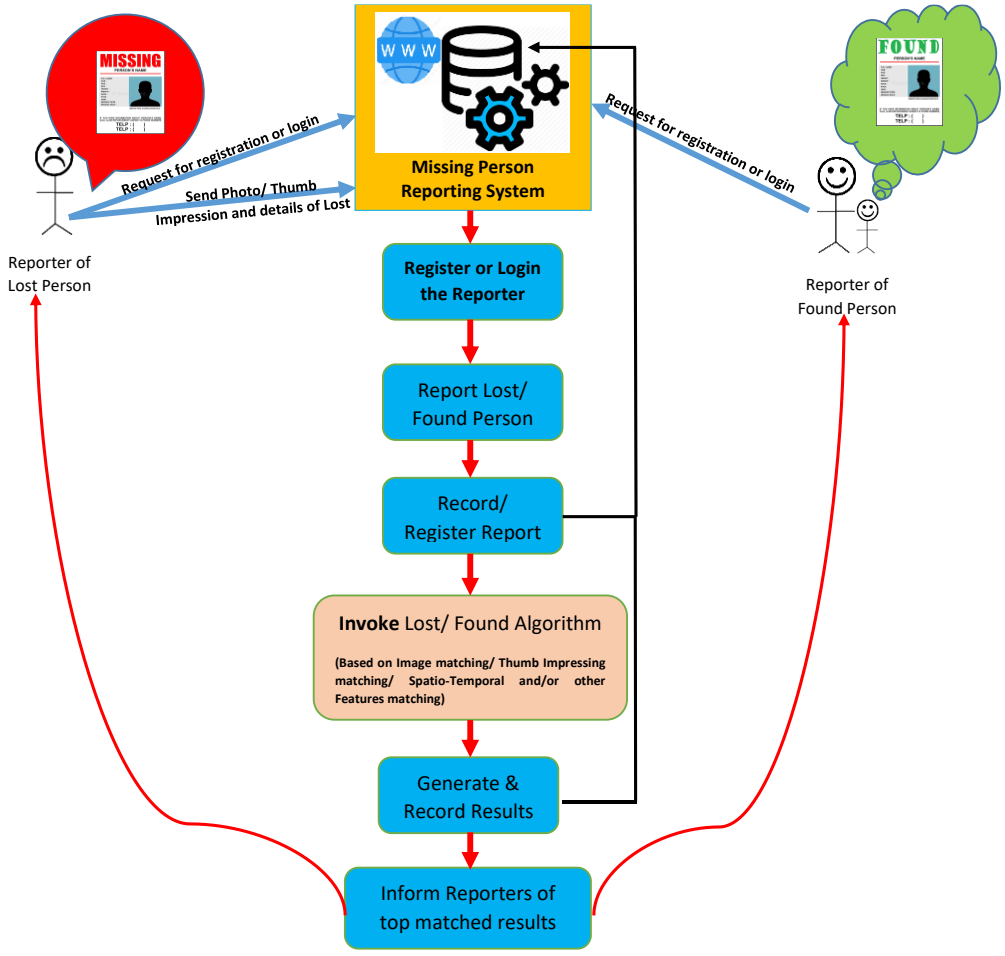


Figure 3. Methodology of proposed model with data flow integration with existing system

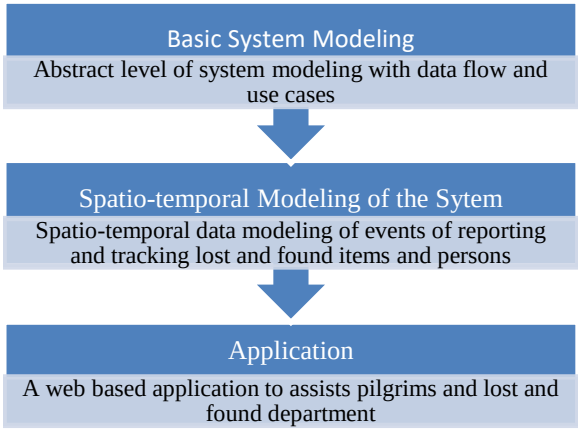


Figure 2. Propose phases of reporting and tracking lost and found items and persons

A. Basic System Modeling

We now briefly present our basic system modeling through a workflow diagram. For example, "Fig. 3" shows our methodology with the flow of data. The pilgrim or visitor who lost his item must first register on the web service and then he can report the missing item by providing all its details including time and location online. The pilgrims can then track the status of their reported lost item. The system generates an alert in case a found item matches with reported items present in the spatio-temporal database of lost and found department. It further notifies the pilgrims through a SMS on mobile to collect their items from the department. The diagram shows first the user register with the application to either report lost and found item or track them. Then the pilgrim can report lost item which is saved in a spatio-temporal database. In case, when an item is found, we have an actor named as "visitor", who found item, first, he must register on the web page and then he can report the items which he found it. The system will notify the pilgrim of his found item and request for the collection from the Department of Lost and Found in the Masjid-e-Nabvi. There is also an option for the custom search based on spatio-temporal features for accurately locating a specific item. Finally, verify the ownership of the item. In this use-case, we have two actors, officer of lost and found department and visitor who lost items. The main process involved are asking for the description of items with pilgrim claiming then these details are compared with

the physical item found. Evidence of collected items is recorded through a form.

B. Spatio-temporal Modeling of the proposed system

Now we present spatio-temporal modeling of the system including the events, spatio-temporal constructs, interaction of moving subjects using an architecture, data storage, and retrieval modeling. We also indicate the limitations of our proposed system. This modeling in the second phase may involve putting some of the functional requirements related to the proposed system in the context.

"Fig. 4" shows the spatio- temporal constructs used in modeling the proposed system. The diagram first shows the relationship between the events and moving objects. The and events are identified as the results of the basic modeling moving objects are pilgrim's visitors and administrative staff of mosques in Makkah and Madinah. As can be seen from the diagram in "Fig. 4", the relationship is represented as prepositions. Then we identify the spatial features which include the geofences of the mosque in Madinah and Makkah. We also identify two temporal features. Now in "Table-I", we will define the time construct including their detail definition with the context of the system.

TABLE I. TEMPORAL CONSTRUCT OF THE PROPOSED MODELING

Construct Type	Definition
Valid Time (VT)	Valid time of tracking lost item is the date and time since the item is reported till it gets marked as found/ delivered.
Transaction Time (TT)	Transaction time is the time when the item was lost or reported or matched/found or delivered.

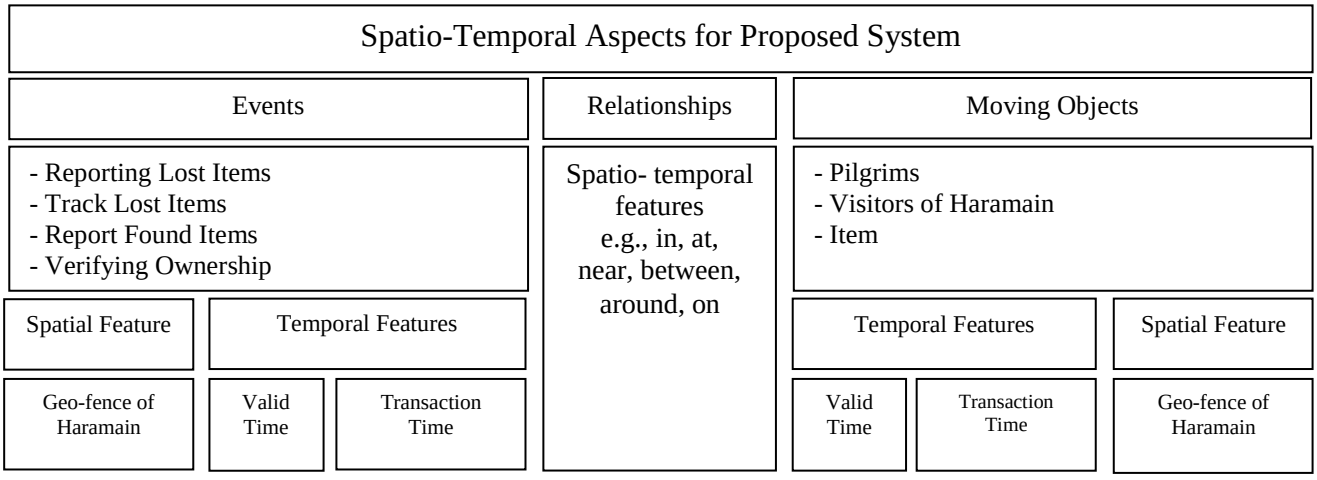


Figure 4. Spatio-temporal construct for proposed lost and found items and persons

TABLE II. TEMPORAL CONSTRUCT OF THE PROPOSED MODELING

Function	Description
addNotification()	This function is used to show notification when user gets out from his current fence. It takes Title of message and text of message as an input.
Userprofile()	First time enrolment of the user to the database. Keeping in notice that no replication is made.
SetupFence()	This function is used to draw polygon on a google map. It takes fence points and google map instance as an input.
RemoveFence()	It is used to remove polygons from google map. It takes map instance and polygon list as an input.
onReceive()	It is a Broadcast receiver function which is used to receive response from background service (API response). It requires current context and intent response.
CheckFence()	It checks whether user exists in current fence or not. If not exists, then it calls addNotification method to notify user about its position.
Loginauthentication()	Authentication of login id and password
UpdateTimezone()	Automatically shifts the time zone of the application according to the GPS Coordinates
Nativelanguage()	Shift the app language to the language selected in the user profile.
Salahtimings()	It uses the database and get the Namaz timings according to the time zone of the user
Supplications()	It helps the user with voice and other tutorials/Dua's according to his/her current fence.
VerifyLocation()	Notify the user if he/she is out of the fence with respect to time and date.

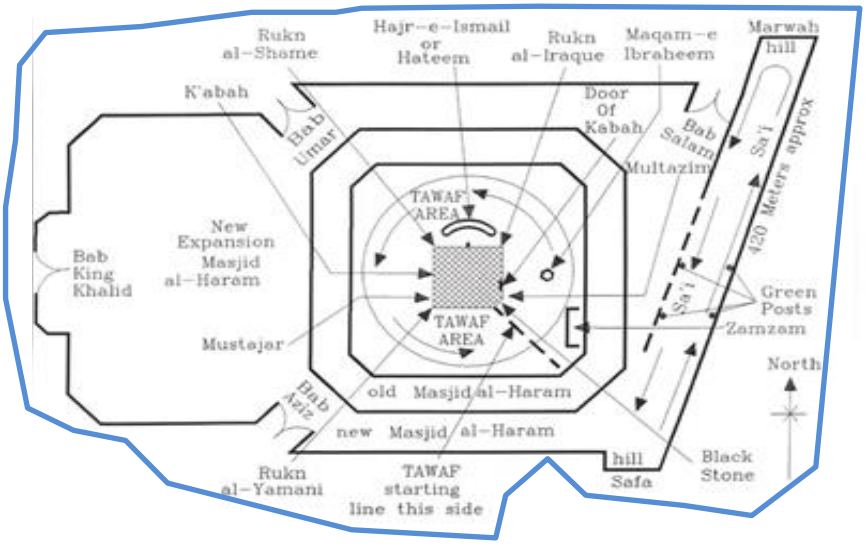


Figure 5. Geofence of Masjid-Al-Haram with Gate details [14]

Spatial constructs are the geofence of the mosque in Makkah and Madinah. The geo-fence is a virtual parameter of interest on the map which is selected by user (either Masjid-Al-Haram or Masjid-An-Nabavi Sal-Allah-o-Alaihi-Wa-Sallam) to mark the spatial boundary of search space by application. The virtual boundary of the mosque may explain further details of the mosque having the name of gates, which will be used as nearest landmark for reporting lost and found items. "Fig. 5" illustrates the geofence of Masjid Al-Haram we use proposed in [14]. As we know that this fences is a sequence of points that form a polygon.

For example, if a person lost his passport, he would report online with his current location and the nearest landmark as King Abdul Aziz gate. This spatial feature along with the time construct will help find the lost item efficiently. A similar fence of the mosque in Madinah may be set up based on the gate number including the landmark's information, be stored as the coordinates of the boundary (fence). This will help along with the temporal information to efficiently search the missing item or person within the boundary. The pilgrims may connect to the web service using the internet on their mobile and access the application interface as shown in "Fig. 6". The pilgrims report an event that is either missing items or persons by providing either spatial or temporal information. Then, spatio-temporal data and event handlers will store the data in the local database. In case pilgrim visits the Lost and Found department in person to report then the staff will have the option to also access using the web service and report the event on behalf of the pilgrims and it will be stored in the local database with all spatio-temporal information. Some of the governing functions of the proposed application that may be included are listed in "Table-II". The proposed spatio-temporal database handler is developed to post data about the missing object from the web application's interface. This data will be required to get parsed by the spatio-temporal data parser and forwarded to spatial and temporal data handler respectively. Spatio-temporal event procedures and constraints to be checked for reporting lost items. The constraint is that the item is reported invalid time. (Here, currently, this proposal has the limitation that loser reports first or the founder reports first). Then spatio-temporal relationship manager will be mended to relate the parsed data with the event's domain. At this point, the equivalent SQL expression and query manager is used. Finally, the physical storage of data will have to take place in three instances; first contain spatial features, second store temporal features and the last on stores information related to the object and pilgrim (Loser/ Founder).

There are some other limitations as well in this proposal. We have sketched a very initial level of information in this paper. Surprisingly, the overlapping of valid time start has a variation with respect to reporting, whether, loser reports first or the finder reports first. Hence, only designed to display the testing of a study carried out so far. Nevertheless, a database workflow is sketched in "Fig. 6".

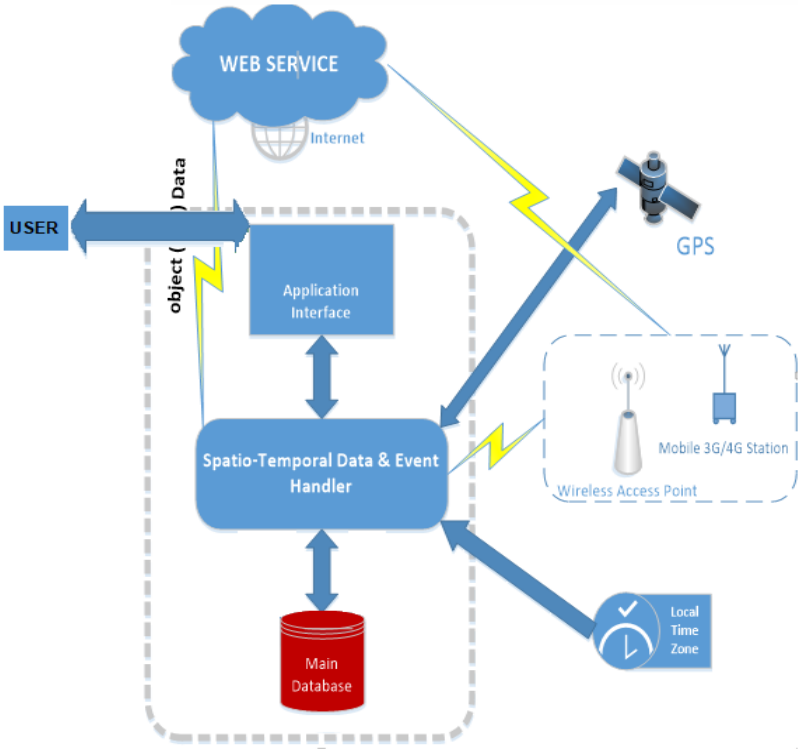


Figure 6. A sample sketch for automatic spatio-temporal feature logging

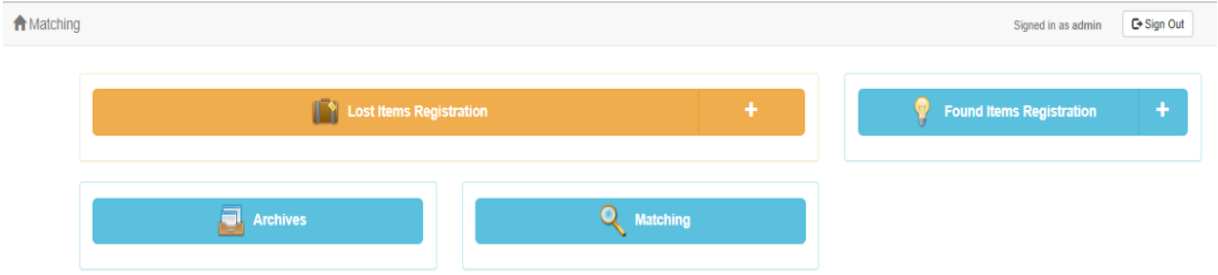


Figure 7. Shows the admin panel of the web service application of proposed system

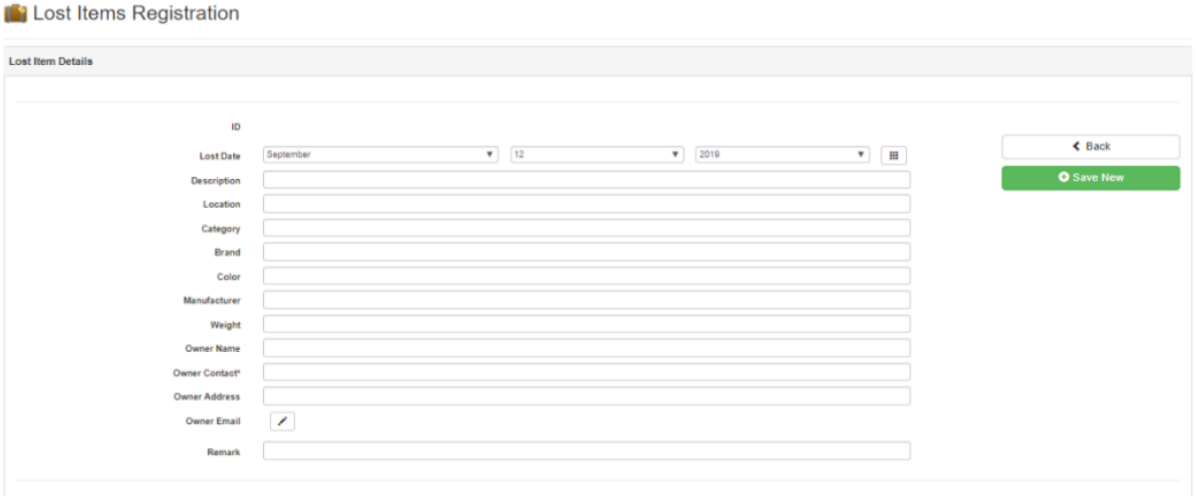
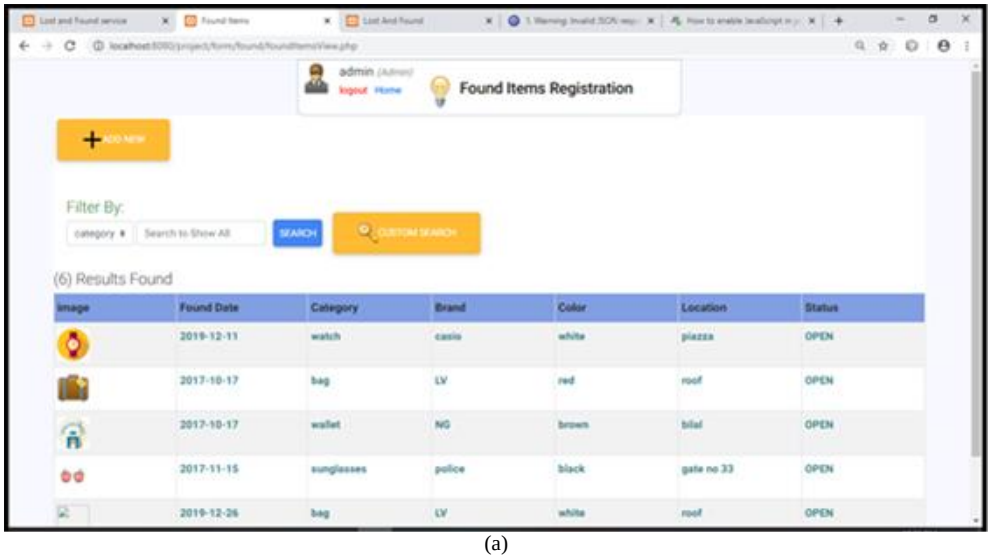
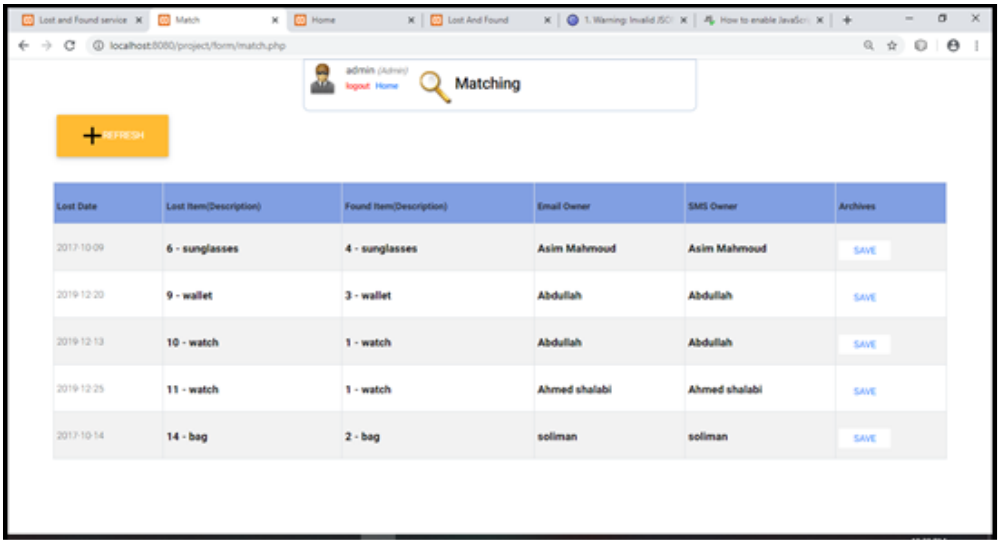


Figure 8. Interface to report lost and found item using web service of the application



(a)



(b)

Figure 9 (a) and (b). Found item report and automatic matching report of lost items produce by the application

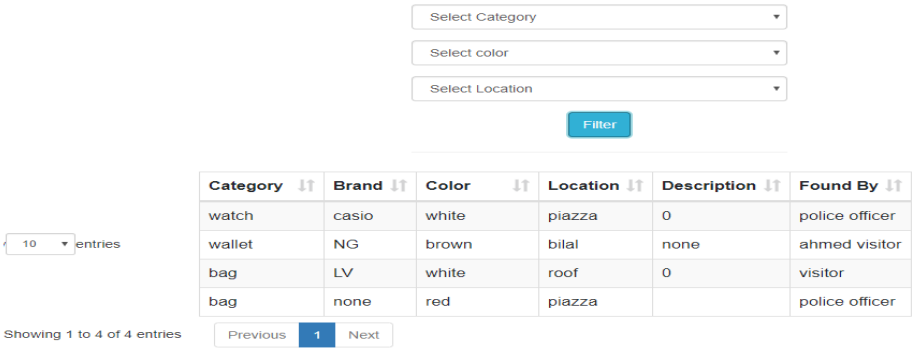


Figure 10. Custom on demand search report by the application

C. Initial Implementation of Proposed System

An initial prototype of web service has been implemented for online registration, reporting and tracking lost items.

This web service has an interface for both pilgrims and the administration. The diagram in "Fig. 7", shows the admin panel which shows the activities can be performed by the administrator. "Fig. 8" shows the interfaces for the lost and found item registration including the details pilgrims have to fill in related to the item he or she lost or found in either mosque in Madinah and Makkah.

The system invokes matching automatic item matching function periodically based on item category, make and color and display a report of matched items as shown in the screenshot at the left side of "Fig. 9".

The administrator can choose to send email or SMS notification to the owner of the item as shown in the screenshot at right side of "Fig. 9". The application also allows the administrator to perform custom search on demand of the visitor by specifying various spatio-temporal parameters for efficient tracking of lost items as shown in "Fig. 10".

5. Conclusion and Future Work

In this paper, we investigated the issue of lost items in a huge crowd gathering scenario of Hajj and umrah. We first study the current system of the Department of Lost and Found in the mosque in Madinah and also conducted a survey with pilgrims about the awareness of this facility. The survey results show most of the pilgrims are unaware of the facility and those who know to find it difficult to report and track their belonging mainly due to the language barrier and manual reporting. In this paper, we proposed spatio-temporal modeling for efficient online reporting and tracking of missing items with an initial implementation application. We observe that the features of time and space increase the effectiveness of reporting and tracking for the pilgrims as well as the management of the Department of Lost and found in terms of the increased number of found items delivered to pilgrims and overall improved process of lost and found department. In the future, we aim to develop a complete working solution for efficient reporting and tracking of missing persons in a huge crowd.

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