A Semantic Geo-Tagged Multimedia-Based Routing in a Crowdsourced Big Data Environment

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ABSTRACT
Traditional routing algorithms for calculating the fastest or shortest path become ineffective or difficult to use when both source and destination are dynamic or unknown. To solve the problem, we propose a novel semantic routing system that leverages geo-tagged rich crowdsourced multimedia information such as images, audio, video and text to add semantics to the conventional routing. Our proposed system includes a Semantic Multimedia Routing Algorithm (SMRA) that uses an indexed spatial big data environment to answer multimedia spatio-temporal queries in real-time. The results are customized to the users' smartphone bandwidth and resolution requirements. The system has been designed to be able to handle a very large number of multimedia spatio-temporal requests at any given moment. A proof of concept of the system will be demonstrated through two scenarios. These are 1) multimedia enhanced routing and 2) finding lost individuals in a large crowd using multimedia. We plan to test the system's performance and usability during Hajj 2015, where over four million pilgrims from all over the world gather to perform their rituals.

Categories and Subject Descriptors
H.2.8 [**Database Applications**]: Spatial databases and GIS
H.2.4 [**Information Systems**]: Query Processing

General Terms
Design, Algorithms.

Keywords
Crowdsourcing, Geo-Tagged Multimedia, Semantic Multimedia Routing, Spatio-temporal Multimedia Queries.

1. INTRODUCTION
Hajj poses a unique challenge to existing routing applications due to the fact that more than 4 million pilgrims with diversity in language, level of education, and culture come to Makkah city mostly for the first time with limited or no prior knowledge of using routing through smartphone [1]. Hence, finding lost individuals or POIs in such a large crowd poses a great difficulty for pilgrims, event organizers, ministries, governments, health industries, emergency departments, and family members. The recent advancements in technologies have contributed in making the high-speed network more available and the location and multimedia enabled smartphones more accessible. As a result, the number of pilgrims sharing geo-tagged multimedia data, which carries semantics, have increased manifold, making crowdsourcing a reality. We argue that adding semantics in routing with the help of multimedia could make it easier for pilgrims with limited or no prior experience of map-based routing techniques to find each other and locate POIs.

In this context, we present a novel semantic multimedia enabled routing mechanism to display routes that is easy to understand and can be used by most users. The system also provides constraint and context-aware multimedia information for POI exploring service. This will further help users to know the semantics of route with respect to their current location in real-time. For example, in case a user submits a query for a hotel, the system will show live results from all the nearby hotels with dynamic information such as vacancies, charges, images of nearby landmarks, available public and private parking with images, customer reviews and traffic constraints.

Although geo-tagged multimedia has been used in many scenarios in the past but none has used in the field of adding semantics to routing. For example, in [2], the authors have used geo-tagged tweets to identify traffic constraints such as accidents and roadblocks whereas in [3] the authors have used a semantic algorithm to recommend interested POIs based on data collected from Foursquare and Instagram. Our system stands out from [2, 3] in that it 1) collects the source and destination of the route from the geo-tagged multimedia information submitted in real-time for route discovery 2) shows the publicly available POIs with multimedia associated with it within a certain radius of the calculated route to semantically help the user(s) and 3) indexes the different types of multimedia data separately in a spatial big data repository for an efficient real-time retrieval. Moreover, we have enhanced the indexing method [4] to support different types of real-time multimedia data with high arrival rates.

2. HIGH-LEVEL ARCHITECTURE
Figure 1 shows the high-level architecture of the system. The system augments multimedia element to conventional routing using SMRA. Apart from the aggregated geo-tagged multimedia data, the system uses road network represented as graph G = (N, E) where N and E are the nodes and edges respectively for calculating the route. We divide the spatial area into cells; each

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cell is of size (one latitude degree * one longitude degree), using a grid approach for efficient retrieval of multimedia data and traffic constraints. Constraints include user choice, accidents and roadblocks. The system aggregates both the publicly available geo-tagged data from social media (crowdsourced data) such as Twitter, Flickr, Instagram and destination, metadata of the multimedia, date and time, and multimedia payload including audio, video, image, text, location, time and user profile.

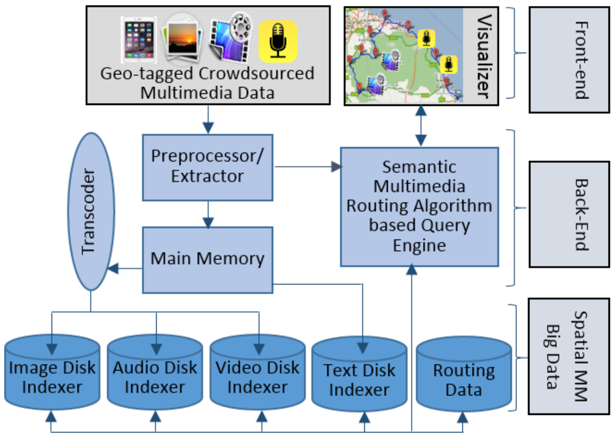

Figure 1. High-level architecture

The preprocessor receives the crowdsourced multimedia data for extracting the location of user and media and input data for spatio-temporal queries (see Figure 2(B)), which is forwarded to the query engine and main memory respectively. Then, the system preprocesses the data and index in the main memory temporarily to answer the fast retrieval of recent data. Based on a predefined threshold value, a flushing process moves data from the main memory to the Spatial Multimedia Big Data repository, where we employ multiple indexers for each type of geo-tagged multimedia data that are stored in big data repository and indexed based on location and meta-data. Each multimedia data is labeled with nearby edge ID and cell ID. The Transcoder transforms the multimedia data in different resolutions to support diversified user bandwidth and resolution and finally stores the original and transcoded media in the Spatial Multimedia Big Data. SMRA based Query engine processes the spatio-temporal queries by fetching the routing information, user constraint such as bandwidth and resolution, media preference and data type etc. from the preprocessor, generates dynamic route, augments geo-tagged media with appropriate resolution and shares the resultant route to the visualization interface (see **Figure 3**). Visualizer displays the results of multimedia enhanced spatio-temporal queries on a map, both online and offline.

3. DEMONSTRATION SCENARIOS

To validate our approach, we developed a prototype based on twitter data as social media and user generated data through our developed smartphone application for Saudi Arabia. The following two scenarios were selected to demonstrate the system's capability.

Scenario-1 Multimedia enhanced routing: It add semantics to the traditional routing to make it more effective in helping users, for example, in a simple navigation scenario such as "take a right turn after the Radisson Hotel" would be more effective if an image of the hotel were also displayed. In this scenario, the system displays the geo-tagged multimedia data along with the conventional route using the query pseudo code shown in **Figure 2** and the corresponding visualization is shown in **Figure 3(A)**. As shown in **Figure 2**, we extend the traditional routing by adding several semantical elements into it (see **Figure 2(B)**) such as type and source of media, types of POIs, and temporal range.

*SELECT * FROM mmData JOIN*
*((SELECT * FROM shortest_path(*
……………)) ← A B →
AS route ON mmData.gid = route.gid
Where (mmData.msgType = 'Image' or mmData.msgType = 'Text') and (mmData.source = 'Twitter' or mmData.source = 'OwnApp') and (mmData.poiType = 'SuperMarket' or mmData.poiType = 'Restaurant') and mmData.date >= '2015/05/25';

Figure 2. A) Conventional shortest path query and B) spatio-temporal query operator to support multimedia enhanced routing

Scenario-2 Finding lost individuals in a large crowd using multimedia: In this scenario, users can share just geo-tagged multimedia data with each other and the system extracts the locations from that geo-tagged data and provides multimedia aided navigation as shown in **Figure 3(B)**.

(A) **(B)**

Figure 3. Scenarios where multimedia is used to add semantics A) multimedia enhanced routing and B) finding lost individuals

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