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Natural Language Interface for Sensor Networks

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Abstract: Sensor networks have a number of applications in military, industries, health and other commercial and non-commercial institutes. Many people working in these different areas may not be technical persons to the query or other similar type languages. The user of these environments may be interested to retrieve data of their interest, but they cannot query the sensor networks because they do not know the query language. This paper proposes a Natural Language Interface to Sensor Networks (NLISNs) so that a non-technical person may be able to query sensor's data. Since most of the users of sensor networks are non-technical for example Biologist, Military person etc. Therefore, this work will enable these persons to query and analyze the data of sensor networks. The accuracy result of the proposed system is 74%.

Key words: Sensor Networks · Natural Language Query

INTRODUCTION

Sensors have a variety of application in today's ubiquitous computing environment. It has a number of applications in Military, Environmental studies, Health, Home appliances and other commercial applications [1]. It provides many useful functions by sensing the condition of physical, biological, chemical and meteorological phenomena in order to build expert systems in areas, such as, animal tracking, precision agriculture, risk monitoring, or hazard management. Therefore, it becomes challenge for the external users or systems to discover and invoke the sensor-derived data [2].

Three different approaches are used to get data from sensor, are mentioned in the existing literature [3]:

Event Based Approach: Events are registered with sensors which return data when that event occurs. These events are pre-programmed in the sensor chip.

Query Based Approach: In this approach the sensor returns data whenever a query is sent to the sensor network from the base station.

Periodic Sensing: The sensor always senses data and it is returned to base station on periodic basis, after some fixed interval.

The problem being addressed in this paper is to make it easier for a non-expert to interact with sensors. One of potential solution to this issue is to design a Natural language interface for sensor networks. The area of NLP (Natural Language Processing) is an active research area. An area in which NLP systems are powered enough to be used in database query systems [4]. Research is going on Natural Language interfaces for databases, but little work has been done in the field of sensor database. Literature [5-7], are using natural language interface to data, but they are focussing on relational database as their target source.

The work of this paper focuses on the query based technique to retrieve data from sensor network, but there are many Non-technical persons, which might face problem in query writing because of not being familiar with query languages, for example, the persons who are working in Military, Environmental studies, Health and Home appliances etc. Therefore, this paper concentrates on the Natural Language Interface for sensor networks in order to enable a common person to query sensor's data. The experimental results show 74% of success rate for the translation of natural question to SQL query. The remaining suggested queries need minor changes from user interface, which is provided in the implementation of system. Rest of the paper is structured as follow: Literature review is discussed in section 2.

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The section 3 is about the Architecture of the Proposed Query System and section 4 explains the Working methodology of the proposed system. Section 5 discusses the Implementation of the system. Section 6 is about the experimental results and section 7 concludes the work done.

Literature Review: There is a lot of work done in the field of sensor networks. This section gives an overview of the related work.

TinyDB [7] is a query based system for retrieving information from a sensor network. The TinyDB collects data from sensor nodes in the environment, filters the required data, aggregates it together and routes it out to a PC according to the user query. TinyDB is limited because it works only with TinyOS.

COUGAR [9] is another query based technique. The COUGAR System is a platform for testing query processing techniques over ad-hoc sensor networks. The COUGAR system makes clusters from sensor nodes in order to reduce the energy consumption.

Zhang *et al*. [10] proposes a cluster based query protocol for wireless sensor networks to save energy. They claim that the protocol uses self-organized sensor clusters to register queries, process queries and disseminate data within the sensor networks. The protocol can efficiently locate the sensor within the sensor field.

The work of [11] proposes a design and implementation of an intelligent system that interacts with system using English as a natural language and retrieves data. Sebastian *et al*. [12] uses natural language interface to analyse the medical data. A dictionary of standard medical vocabulary is used for this purpose. In [13] an ontology based natural language based interface is used for querying the Power Quality data, which is collected through mobile measurement system. Young *et al*. [14] propose a natural language based interface model to enable a user to communicate a mobile device without having specific knowledge about it.

Most of these techniques use query based approaches to retrieve data from sensor networks, but they are limited to SQL based technique. The query language may be difficult to understand by the non-technical people who are using sensor data from sensor networks.

Architecture of the Proposed Query System: Figure 1 shows proposed architecture of the query system which can work for both the natural language and query language.

Different components of the proposed architecture are explained in the following sub-sections. In these components some are on the base station and other are on the sensor networks.

Component on the Base Station: Following are the components of the base station. Base station is normally a powerful node and resources may not be a problem.

User Interface: User issues his/her query to the sensor node through User Interface component. User must select a language to pose his/her query. The architecture has two languages components.

- Query using a Natural Language
- Query using a Query Language

Query Using a Query Language: This component directly accepts the request in the form of a query. This component is for those users who know the query language, so they can directly pose their queries through this component.

Query using a Natural Language: In this component the user writes his/her query using the Natural Language. This component is for those users who are not technical in query writing and cannot pose their query using the query language.

Query Manger: Query Manager is an important component. It takes user's Natural language query from the user through "query using Natural language" component and converts it to proper query with the help "Corpus of Natural language Query" component.

Corpus of Natural Language Query: It is a collection of a large corpus containing the possible queries to sensor network data. Since the base station has no storage problem, therefore, corpus is stored on base station.

Components on Sensor Network: Following are the components on the sensor network

Query: Query is the actual request of user which is to be sent to the sensor node.

Sensor Data: This is the actual data which is stored on the sensor node. Then the "Retrieved Data" component contains the result of the query based on user request.

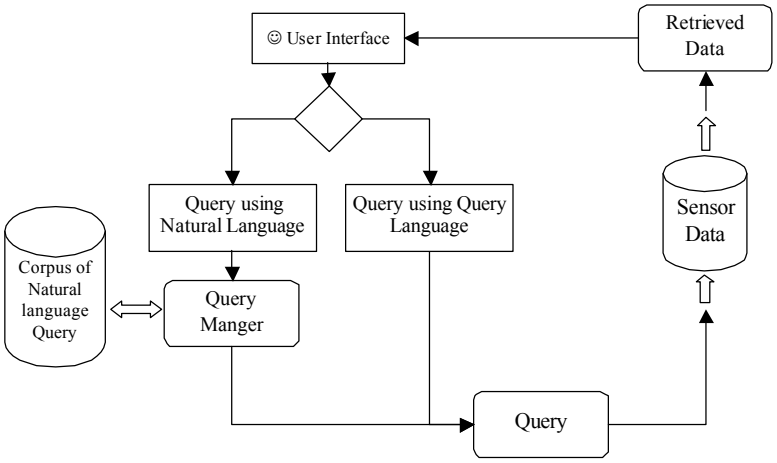

Fig. 1: Architecture for proposed query based system

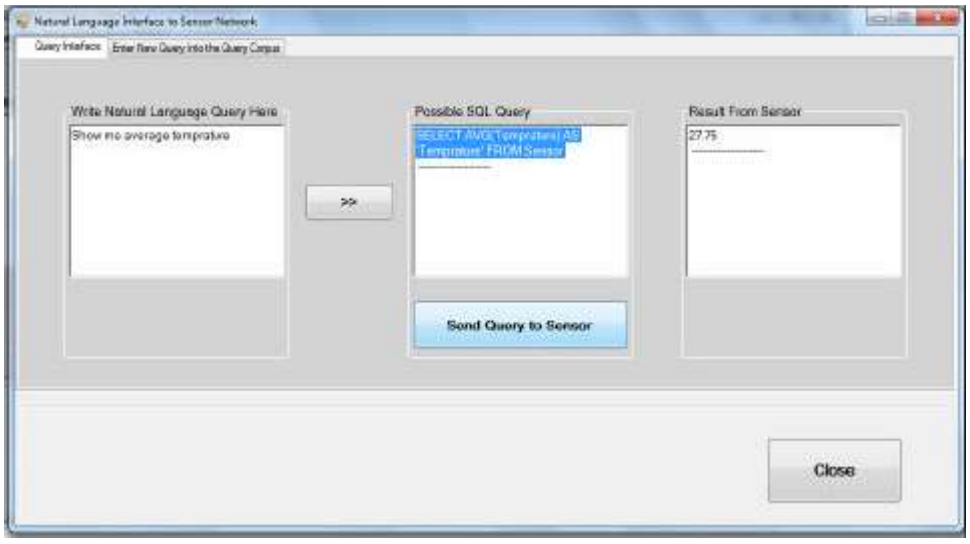

Fig. 2: Main interface of proposed system

Corpus Based Solution: A corpus based solution is proposed for the system because sensor data is specific and not general, therefore, the number of queries toward sensor network is also limited and specific. So, it can easily be stored in a corpus for the use of query manager as compared to traditional database which has very different type of data and queries.

Working Methodology of the Proposed System: Consider the Figure 1, the user poses his/her query through the User Interface component. Then the nature of query is checked that whether it is a natural or query language type query. If request of the user is through query language then query is directly sent to the sensor networks and the required data is obtained. Otherwise, if the request is sent through the natural language then query manager builds a query from the user request with the help of "Corpus of Natural language Query" component. After this the query is sent to the sensor networks and to obtain the results.

Implementation of Proposed System: A prototype of the system has been implemented in C#.NET as an interface and SQL Sever is used as sensor database. A high level language can be used because the interface runs on base station. The base station is normally a powerful node and resources may not be a problem for it. For example, base station may be a laptop or a PC (Personal Computer). The figure 2 is the main interface of the proposed system.

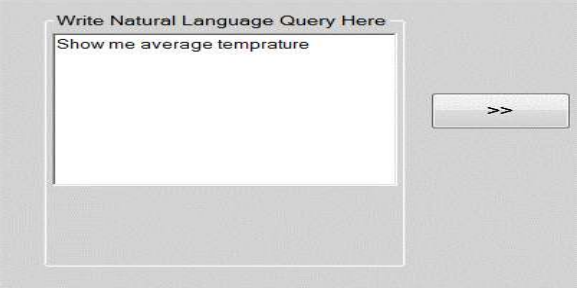

Fig. 3: Figure of Natural Language Interface textbox in the proposed system

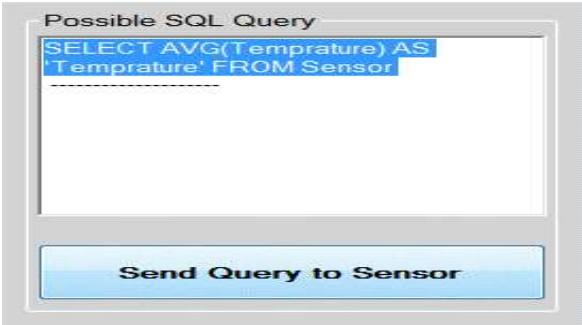

Fig. 4: Figure showing the possible SQL queries of Natural Language query to user

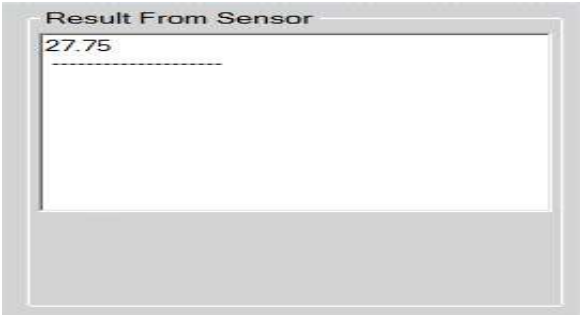

Fig. 5: Figure of Textbox showing the result returned from Sensor based on query

In figure (Figure 2), the first textbox is used for user to enter his/her natural language query (question) and press the convert button (>>). After pressing the convert button the user gets one or more than one possible SQL queries. More than one SQL queries are possible in case of an ambiguous natural language query. The user can select the appropriate query from possible queries by selecting it as shown in figure (Figure 2). The user needs to press the "Send Query to Sensor" button after selecting the query in the "Possible SQL Query" textbox. The result from sensor is displayed in the "Result from Sensor" textbox. Following are the screenshots of each individual component.

Experimental Results: A prototype is implemented for experimental purposes. Different type of queries were issued in natural language and translated to query language. Total 150 questions were asked in natural language out of which 111 questions were translated successfully. The percentage of accuracy is 74%. The remaining questions which were not translated successfully, requires minor modification from user interface using the suggested query of the system (as shown in Figure 4). This modification facility is provided in the system's implementation.

CONCLUSION

Sensor networks have many applications and can be applied in different fields. This paper proposes a natural language interface to sensor networks in order to enable the non-technical person to issue queries to sensor networks and analyse data. The accuracy of the query manager is 74%. This could be further improved by expanding the corpus and adding new services to the architecture.

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