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A Study on Web Intelligence for the Internet of Things

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Abstract--- *The Internet of Things (IoT) is a widely evolving platform tending to automate ones daily actions, thereby reducing the extent of human efforts. The aim is to find various methods using which Web Intelligence & IoT can be enforced, taking into consideration efficiency and other economic constraints. This paper discusses on the different methods that are adopted while applying Web intelligence techniques with IoT in various fields in the real world. Using various branches of Web Intelligence like Semantic Web, Information Retrieval and Data mining the applications of IoT are explored.*

Keywords--- *Web Intelligence, Internet of Things, Data Mining*

I. INTRODUCTION

Advancements in Technology and a mechanical life keep individuals, busy and preoccupied. Hence less time is available towards the completion of daily chores which by the end of the day, seem the most stressful work to be carried. IoT helps in inter-communication between machines using the latest software and hardware that help in performing actions, with great accuracy and precision with very less initial work required to be performed to initiate these action. Web Intelligence is the one that facilitates inter-communication between devices. The World Wide Web plays as the intermediate through which transfer of information and communication takes place between two or many Artificial Intelligence (AI).The purpose of this paper is to explore the various fields in IoT and prominent fields in which IoT can be applied. The remainder of the paper is going to shed light over: Section 2 gives us a brief about the usage of Semantic Web in IoT. Section 3 discusses on Information Retrieval with IoT and Section 4 comprises of Data Mining with IoT. Finally, conclusions are made as a part of Section 5.

Semantic Web and Internet of Things

Ali Yachir et.al [1] had proposed semantic model where the ontological techniques were used on, IoT devices and resolving user requests, facilitating machine to machine communication and reasoning facilities over service data. A four system framework (human, space, appliances, IoT Device) was designed where the IoT device was the central entity enforcing work at the command of humans.

The user requests were resolved using description logics which were termed functional requirements and it also was termed non- functional requirements when the process depended on the quality of services. Nicole Merkle et.al [2] came up with a framework making integrating heterogeneous devices easier for the Elderly and the blind. Further

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a light weight Ambient Assisted Living (AAL) ontology was proposed using their own rule based engine (Sherlock). By interconnecting devices in ambient environments they enabled the Sherlock engine deduce server linked intentions. The engine though being unable to deduce in an uncertain situation as it was independent, it was a suitable solution for the devices used and the services that were present. Mahsa Teimourikia et.al[3] proposed a decision support system for run-time safety management in Smart Work Environment(SWE).Based on Based on OSHA , MAPE-K loop standing for Occupational Safety and Health Regulation and Monitor-Analyze- Plan- Execute and Knowledge respectively a tool RAMIRES (Risk Adaptive Management In Resilient Environments &Security) was proposed. The tool communicated the risks and preventive strategies, obtained more data on the obtained area in order to understand the risk and consequences and also execute the automatic preventive strategies and supported in the execution of human-operated preventive strategies. RAMIRES being a dashboard implements the various methodologies proposed towards run-time safety. Using OSHA and EU-OSHA generic safety ontology was proposed Wei Wang et.la [4] focused on a light weight and comprehensive description model for representation of knowledge in the field of internet of things. The most common and widely used knowledge engineering and ontology modeling were used and the major advantage of this model was its scalability. It was observed that modeling using semantic technologies showed considerable effectiveness for supporting the interoperability among the various distributed and heterogeneous sources on the IoT. A description ontology was presented was presented which integrated the existing efforts for modeling the IoT domains main concepts. However the comprehensive model lagged in efficiency to contribute towards research on IoT. Stefan Zander et.al [5] demonstrated a formal model semantic of Ontologies which enhanced the utilization and the interoperability of the IoT. Basic technical information in the RDF format are automatically used to classify these devices. The Demonstration revealed that the interpretation and expressiveness of the IoT device can be significantly improved using semantic description frameworks. The limitation of the method proposed is that open world semantics are counterproductive and limit the set of additional information that can be inferred .Semantic Web and Ontology are used in IoT to provide a framework and design to the working of the IoT device. Using Semantic Web in IoT is found to be a very efficient technique, which is to be exploited for a wide and efficient usage of IoT.

Information Retrieval and Internet of things

Mangala Madankar et.al [6] explains on retrieval of information from cross lingual, multi lingual and techniques for machine translation. The method deals with queries in one language and retrieved documents in some other language while MLIR DEALT with queries and retrieval from one or more languages. CLIR and MLIR were made possible through machine translation techniques. CLIR and MLIR were designed using machine translation which is a real hard problem due to common words used in many languages. Mehdi Adda et.al [7] proposed a framework, specific language and an integrated development environment to implement the presented model. The framework rather relayed on queries and responses to the queries and a white list /blacklist policy. A real world experiment was carried out to check the scalability and performance of the proposed model. Jose Quevedo et.al [8] explains the integration of Information Centric Networking concepts with IoT. Named Data Networking (NDN), a service discovery mechanism was proposed through which the process of discovery was a lot easier and made use of matching mechanism.

The key features were the appropriate service discovery mechanisms that were used to enrich the understanding capabilities to process context information. A prototype was developed and tested experimentally. The usage of semantic matcher as a part of the service discovery solution increased the flexibility enabling precise matching of queries and responses. Daniela Ventura et.al [9] focused on implementing a restful infrastructure that supports internet connected devices. A framework was developed which forecasted the coffee usage pattern for the following week for efficient use and power consumption. These appliances reported the usage pattern through cloud to their framework which was used for predicting the usage for the following week. With the data retrieved from four such machines an accurate prediction matching was made possible. The framework reduced the ecological impact which would be caused due to replacement of old appliances. The rest based architecture proposed lead to eco-aware devices which resulted in carbon neutrality by means of the prediction model.

Emmanuel Kaku et.al [10] proposed a light weight prototype system which traced the source of requests to which responses were retrieved.

Provenance information over CoAp in the Internet of Things was used to build the framework. The framework enabled connecting transmitting and requesting services amongst and between devices creating a lot of new possibilities for applications and services that were initially considered difficult. The provenance based prototype by tracing the source of request formed a chronological history of requests and responses which along with transparency, reliability, Constrained Application Protocol and lightweight protocol enabled the prototype to make inference on the source. The throughput of the highest payload size was 50.1KB/s along with 21ms faster response which differed along with the payload size. Information Retrieval in IoT is considered necessary to predict future usage of appliances, enable translations from one or more languages and improving the efficiency of response to requests amongst devices in ambient environments. Accurate and Precise retrieval of information enables communication between devices easier and accurate actions were carried out as a result of reliable data and information.

Fig.3.1 is about how information retrieval from web is carried out by using Ontologies. Ontology in E health care domain for Mental illness or disorders is drawn. Whenever we try to retrieve this mental illness information, ontology gives us efficient results.

The importance of IoT in information retrieval comes in the collection of large amounts of data and tracking things that are connected through internet. While the ontology based information retrieval is an efficient way to retrieve data which is collected from the connected machines and smart devices through IoT. Because, these connected machines and smart devices generate unfathomable amount of information every minute every day. However, not all this data is useful. But, some of this data can go a long way helping companies do business smarter. Businesses like manufacturing, health care, finance, retail; stocks etc. use some of this data. Huge amounts of this Real-time data collected form smart devices through IoT is then stored in some kind of knowledge graphs like ontologies, using which information retrieval is very efficient. This retrieved information is very important in the field of Business Intelligence (BI).

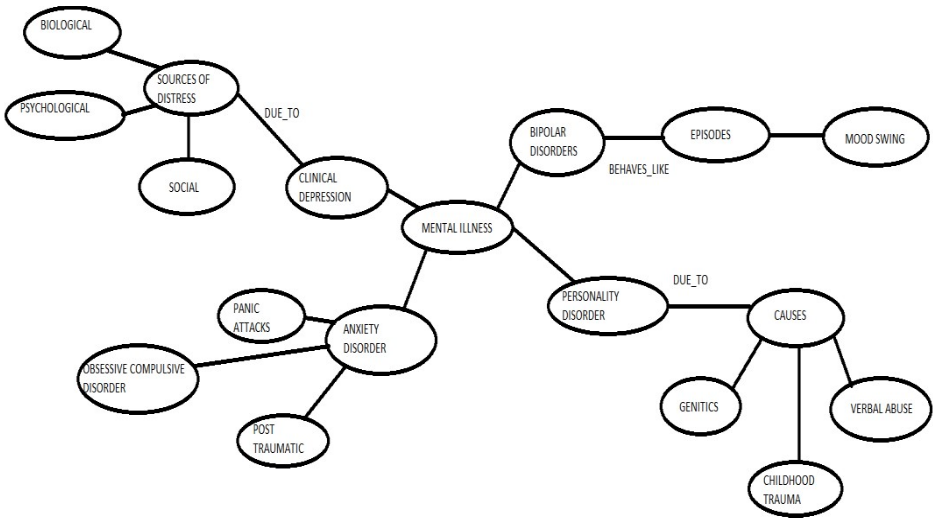

Fig.1.3.1: Ontology model diagram for mental illness.

```
<rdf:RDF
     xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
     xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
     xmlns:owl="http://www.w3.org/2002/07/owl#">
   <owl:class rdf:about="CLINICAL_DEPRESSION"></owl:class>
   <owl:class rdf:about="SOURCE_OF_DISTRESS"></owl:class>
   <rdf:Property rdf:about="DUE_TO">
      <rdfs:domain rdf:resource="CLINICAL_DEPRESSION"/>
      <rdfs:range rdf:resource="SOURCE_OF_DISTRESS"/></rdf:Property>
   <owl:class rdf:about="BIOLOGICAL">
      <rdfs:subClassOf rdf:resource="SOURCE_OF_DISTRESS"/></owl:class>
   <owl:class rdf:about="PSYCHOLOGICAL">
      <rdfs:subClassOf rdf:resource="SOURCE_OF_DISTRESS"/></owl:class>
   <owl:class rdf:about="SOCIAL">
      <rdfs:subClassOf rdf:resource="SOURCE_OF_DISTRESS"/></owl:class>
   <owl:class rdf:about="ANXIETY_DISORDER"></owl:class>
   <owl:class rdf:about="PANIC_ATTACKS">
      <rdfs:subClassOf rdf:resource="ANXIETY_DISORDER"/></owl:class>
   <owl:class rdf:about="OBSESSIVE_COMPULSION_DISORDER">
      <rdfs:subClassOf rdf:resource="ANXIETY_DISORDER"/></owl:class>
   <owl:class rdf:about="POST_TRAUMATIC_STRESS_DISORDER">
      <rdfs:subClassOf rdf:resource="ANXIETY_DISORDER"/></owl:class>
   <rdf:Property rdf:about="DUE_TO">
      <rdfs:domain rdf:resource="ANXIETY_DISORDER"/>
      <rdfs:range rdf:resource="FEELINGS"/></rdf:Property>
   <owl:class rdf:about="FEELINGS"></owl:class>
   <owl:class rdf:about="WORRY">
      <rdfs:subClassOf rdf:resource="FEELINGS"/></owl:class>
   <owl:class rdf:about="FEAR">
      <rdfs:subClassOf rdf:resource="FEELINGS"/></owl:class>
   <owl:class rdf:about="ANXIETY">
      <rdfs:subClassOf rdf:resource="FEELINGS"/></owl:class>
   <owl:class rdf:about="BIPOLAR_DISORDDER"></owl:class>
   <owl:class rdf:about="EPISODES"></owl:class>
   <rdf:Property rdf:about="BEHAVES_LIKE">
      <rdfs:domain rdf:resource="BIPOLAR_DISORDER"/></rdf:Property>
      <rdfs:range rdf:resource="EPISODES"/>
   <owl:class rdf:about="MOOD_SWING"></owl:class>
   <owl:class rdf:about="PERSONALITY_DISORDER"></owl:class>
   <owl:class rdf:about="CAUSES"></owl:class>
   <rdf:Property rdf:about="DUE_TO">
      <rdfs:domain rdf:resource="PERSONALITY_DISORDER"/>
      <rdfs:range rdf:resource="CAUSES"/></rdf:Property>
   <owl:class rdf:about="GENETICS"><rdfs:subClassOf rdf:resource="CAUSES"/></owl:class>
   <owl:class rdf:about="CHILDHOOD_TRAUMA"><rdfs:subClassOf rdf:resource="CAUSES"/></owl:class>
   <owl:class rdf:about="VERBAL_ABUSE"><rdfs:subClassOf rdf:resource="CAUSES"/> </owl:class>
   </rdf:RDF>
```

Fig. 1.3.2: Owl code for the ontology that is shown in Fig. 1.3.1. Showing the relationships between the mentioned classes, their properties and subclasses.

Data Mining with Internet of Things

Md. Mamunur Rashid et.al [11] proposed a new behavioral pattern mining technique using regularly frequent sensor patterns (RFSPs) from sensor data. RFSP having a compact tree structure requires less memory and revealed significant knowledge from the monitored data by identifying temporarily correlated sensors from a single scan of the data set. A distributed extraction model was proposed which used greater redundancy to prepare the data required for mining RFSPs. The proposed model was found efficient and also showed characteristics of low runtime. Parallel to the proposed method Hadoop based RFSP (RFSP-H) mining algorithm was proposed which used MapReduce-based framework as MapReduce model made computation on large data easier. The technique proposed was found out to be very effective and efficient to mine frequent sensor patterns, through comparative performance analyses. Gevorg Poghosyan et.al [12] focused on a new Machine-to-Machine data analysis techniques which go beyond binary association rule mining for traditional market basket analysis. Complex device co-usage patterns of 201 residential broadband users of a particular ISP was extracted based on multidimensional patterns mining framework, which provided valuable insights on upcoming techniques such as adaptive usage of home devices and things recommendation. Furthermore, n-ary association rules for mining device usage pattern in Intranet of Things were explored which provided insights uncovering daily practices of residents. Dimensions of the analytics with application-level gateway were enhanced foreseeing a unified Intranet of Things architecture enabling applications over diverse set of devices. Shen Bin et.al [13] proposed a four data mining models namely, multi-layer data mining model, distributed data mining model, grid based data mining model, and data mining model from multi-technology integration perspective. The first model separated data into four layers: data collection layer, data management layer, event processing layer, and data mining service layer. The second model solved depositing data from various sites. The third model allowed realization of the functions of data mining through the usage of a grid framework .The last model gives the usage of the present framework for the future internet. The complexity of the problems were decomposed showing Improvements in performance, storage capacity, computing power of the central nodes which were reduced significantly. The paper further reveals that a challenging risk of data mining in internet of things are distributed storage, mass-time related/position related data and limited resources of nodes. Furqan Alam et.al [14] examines the applicability eight very commonly used data mining algorithms for Internet of things. To model high level data abstraction Artificial Neural Network (ANN) and Deep Learning Artificial Neural Network (DLANN) were used. Amongst the Algorithms used C4.5 and C5.0 were memory efficient, had high processing speed and had a better accuracy which resulted in the doubt of needing new data mining techniques. Alvaro Villalba et.al [15] presented a platform designed for dredging data associated to Internet of things. This platform associated itself with data from the sensors as well as meta-data. The platform comprised of two components where the first was called servIoticy which stored and processed data and the second was known as iServe which was responsible for the discovery of the sensors meta-data. Both the components where designed so as to enforce scalability meeting the requirements of any IoT cloud deployments. Real time and query data were ingested and transformed through the usage of the former while the latter used the semantic information associated with sensors to publish and discover data. Data mining with IoT is wide field for research. Given the fore sight that the no. of objects connected to IoT is to reach around 50 billion by 2020 the amount of IoT data from all these objects is going to be significantly larger where data mining and other artificial intelligence methods would play a critical role towards the foundation of a smarter IoT.

II. CONCLUSION

Internet of Things is said to revolutionize all aspects of living. With more and more new concepts and fields of usage of IoT devices brings into necessity also smarter methods that provide effective and efficient solutions. This paper discussed the various Web intelligence techniques used for the betterment and improvement of the Internet of Things, enabling smarter simpler and easier access to the data associated with different IoT devices.

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