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Review Article

Towards Enhancement EUPont Ontology for Smart Home

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Abstract: Smart homes are characterized by the integration of technology and services using home networking, with the goal of improving the overall quality of life. When designing these intricate systems, it is important to consider the experiences and needs of the occupants. Smart homes consist of various devices that offer comfort, security, convenience, energy efficiency, and promote intelligent living. These devices communicate and interact with each other, forming a connected ecosystem. In order to ensure prompt assistance during emergencies such as fires, medical emergencies, or distress calls, interactivity and technology within smart homes should enable emergency service providers to quickly respond. To achieve this, a modeling language that supports the semantic aspect is employed, allowing for modeling that closely aligns with end user requirements. This language typically utilizes the concept of ontology. However, the use of ontologies in smart home design is still limited in current research. As a result, this paper aims to enhance the EUPont ontology by integrating Arduino devices and implementing an algorithm that simplifies the analysis of detected alarm signals and user decision-making. The execution of this algorithm relies on the definition of several SWRL rules (Semantic Web Rule Language).

Keywords: Smart Home, Semantic Web, Internet of Things, EUPont

1. Introduction

A Smart home can be described as a dwelling or structure equipped with technology that can be controlled and operated remotely from anywhere in the world using Smart Devices or Smartphone. Within Smart Homes, there are various devices that offer comfort, security, convenience, energy efficiency, and promote intelligent living [1]. These devices communicate and interact with each other, forming a connected ecosystem. While Smart Homes are commonly associated with automation, their capabilities extend beyond mere automation. The Smart Home ecosystem consists of a collection of interconnected intelligent gadgets that are capable of executing tasks and making necessary decisions [2].

Ensuring the safety and security of a smart home remains a paramount concern, particularly within the context of a Smart City. The interactivity and technology within the home should enable emergency service providers to promptly offer assistance in the event of emergencies such as fires, medical emergencies, or distress calls triggered by the smart home users [3]. Additionally, there should be an automatic response system in place that captures vital information, including the precise location and type of distress (e.g., fire, medical emergency, burglary), allowing for the appropriate emergency service to be notified [4]. For instance, within the previously outlined Home Automation system, it is crucial to have available emergency modes that establish a connection with a central government response agency. This agency can then process the alerts and ensure the shortest possible response time, thereby potentially saving lives and mitigating damages, particularly in the case of fires. [2].

Advanced sensors are now capable of detecting instances where an individual has fallen and become unconscious, triggering an alarm and automatically sending a distress signal to an agency or a designated family member. Moreover, sensors have been specifically designed to detect, record, and analyze patterns of movement, footsteps, and the speed at which a person navigates stairs or moves between rooms. These sensors can alert remote family members if there are notable deviations from the expected patterns or if sudden physical weaknesses, collapses, fainting spells, or blackouts are detected. Additionally, certain sensors have the ability to detect irregular heart rhythms or changes in blood pressure. [5].

In this paper, aims to (1) enhance the EUPont ontology [6] and integrating Arduino device to it and (2) an algorithm executed analyze the detected alarm signs and make the appropriate treatment. The rest of this paper is organized as follows depicts a related work about semantic interoperability in the IoT and the smart home field Section II. In Section III, proposed using EUPont ontology [6] in send responding alert system [7] to increase responding time. In Section IV, The proposed using Reasoning Algorithm to analyze the detected alarm signs and make the appropriate treatment and finally, conclusion this paper in Section V.

2. Related Work

The advent of ubiquitous systems in smart environments, including smart homes, hospitals, airports, and universities, has become a tangible reality. However, the utilization of this technology gives rise to various challenges, particularly concerning the sharing and reusability of information, as well as ensuring interoperability between different systems [8]. In this context, several approaches have been proposed to address these challenges and enhance interoperability, with ontologies emerging as a promising solution. By leveraging ontologies, flexible models can be created that guarantee reasoning and inference capabilities. Ontologies find widespread application across diverse domains such as knowledge and content management, e-commerce, medicine, biology, smart spaces, and the Semantic Web. Moreover, the use of ontologies extends beyond reasoning, information sharing, and reuse, encompassing other significant aspects as well. [9].

In a study, the authors developed, implemented, and evaluated EUPont, a Semantic Web ontology. EUPont facilitates the creation of universal and technology/brand-agnostic trigger-action rules that can be effortlessly adjusted to various contextual scenarios and even unknown IoT devices and services [6]. Compared to the commonly employed tool IFTTT, EUPont offers greater expressiveness, enabling end users to fulfill their requirements with fewer rules. By utilizing EUPont, the programming time for IoT applications is reduced, resulting in more accurate trigger-action rules. Additionally, EUPont enhances the discoverability and reusability of these rules.

Similarly, presents the design and implementation of a secure and automated home that utilizes a hybrid communication system, combining IoT and mobile communication methods for seamless connectivity. Components such as Arduino Microcontroller, GSM Shield, Ethernet Shield, and various sensors facilitate the communication aspect of the system. Given the advancements in the IoT domain, there is a growing need for real-time security solutions. A secure and automated home is equipped with electronic devices and sensors to safeguard against intrusions, such as detecting motion within the premises, as well as responding to potential disasters like fires and gas leaks [7].

The authors, Development and execution of an accessible framework and associated methodology to enable seamless communication among disparate IoT platforms. This approach covers various components of the software stack (hardware, network, middleware, application services, data, and semantics) to facilitate unified interoperability [10].

From another perspective, Gyrard and Patel et al. The difficulty lies in streamlining the creation of IoT applications for smart office and fire management purposes. The authors suggest a solution for simplifying IoT application development. However, developers are still required to write code for the application's logic layer, and the authors do not clarify how sensor data should be interpreted. They emphasize the importance of shared domain vocabularies but do not utilize semantic web technologies in their approach. There is no demonstration provided, and there is a lack of end-user interactions [11, 12]. Recently, Hachem In her thesis, Sivieri focused on the utilization of domain experts in interpreting sensor data, a costly and time-consuming process [13]. To address this issue, she highlighted the need for approaches that enable sharing and reusing of interpretation techniques for sensor data. She also emphasized the importance of integrating inference mechanisms in the future to extract higher-level knowledge from sensor data. This is necessary as developers lack the necessary expertise for this task. Sivieri et al. [14] introduced the ERLIoT (ErLang for the Internet of Things) framework to assist developers in testing, debugging, and verifying their code. By utilizing this framework, developers can efficiently develop and maintain IoT applications.

From the general perspective, smart homes incorporate a range of components such as sensors, actuators, embedded microprocessors, smart appliances, software, and networked elements [15]. These components work together to offer various intelligent services for the residents of the home. From a comprehensive perspective, we can outline the defining attributes of smart homes as follows: Firstly, smart homes can be categorized as Complex Systems because they are comprised of interconnected subsystems that exhibit behaviors or characteristics that may not be apparent when examining the individual subsystems in isolation. Secondly, smart homes can be classified as Heterogeneous Systems because they encompass various components such as sensors and actuators, which possess a wide range of structural variations. Lastly, smart homes can be considered as Evolvable Systems due to the ever-changing user requirements and the continual integration of emerging technologies or products into the overall system. Consequently, the composition of smart home features can give rise to challenging issues.

Regarding the detection of policy interactions in smart homes, there is limited existing research on utilizing Semantic Web technologies, which are an emerging field that enables knowledge representation, sharing, and automated reasoning. To the best of our knowledge, little work has been done in this area. While Ricquebourg and Xu et al. have proposed a four-layer architecture for data acquisition in distributed sensor networks within smart home environments, incorporating the use of Web Ontology Language (OWL) for representing semantic context and Semantic Web Rule Language (SWRL) for inference [16, 15].

In the study, the authors design The European Project ontology (EUPont) is a framework that supports the creation of adaptable, technology-independent, and device-agnostic trigger action rules [6]. EUPont facilitates the development of these rules in response to diverse contextual scenarios and future IoT devices, thereby promoting their versatility and applicability. To illustrate, EUPont provides a systematic approach to define actions and conditions based on universally recognizable entities, enabling seamless adaptation to varying IoT scenarios. Additionally, EUPont offers robust and easily comprehensible ontologies that ensure smooth interoperability between IoT devices and platforms, regardless of their manufacturer or specifications. The primary objective of designing a reliable and efficient system using home automation is to address the challenges of monitoring and detecting suspicious activities [7]. This system is intended to alert the homeowner through a message whenever such activities are identified. Therefore, this paper aims to reuse EUPont ontology in [6] rather than message in [7].

3. The Proposed Using EUPont Ontology in Send Responding Alert System to Increase Responding Time

The smart home is illustrated in Figure 1. Shows the flow chart of the system. As it can be seen from the figure. As it is mentioned in [7], the system is comprised of two distinct hardware components: sensors and actuators. The actuators are consistently active and do not require an activation PIN, allowing the user to control electrical appliances both within and outside the home via the internet. Additionally, the system remains responsive to execute requests from either side. Upon receiving a request from the user to activate a home appliance, it will be executed accordingly. Otherwise, it will remain in a waiting state for further requests. On the other hand, the sensors are only activated when an activation code is sent to the system via SMS. Once activated, the sensors will detect events such as motion, gas leaks, or smoke, and subsequently send an alert to the user via SMS. The user can then verify the alert by accessing the camera feed and observing the home before taking any necessary action.

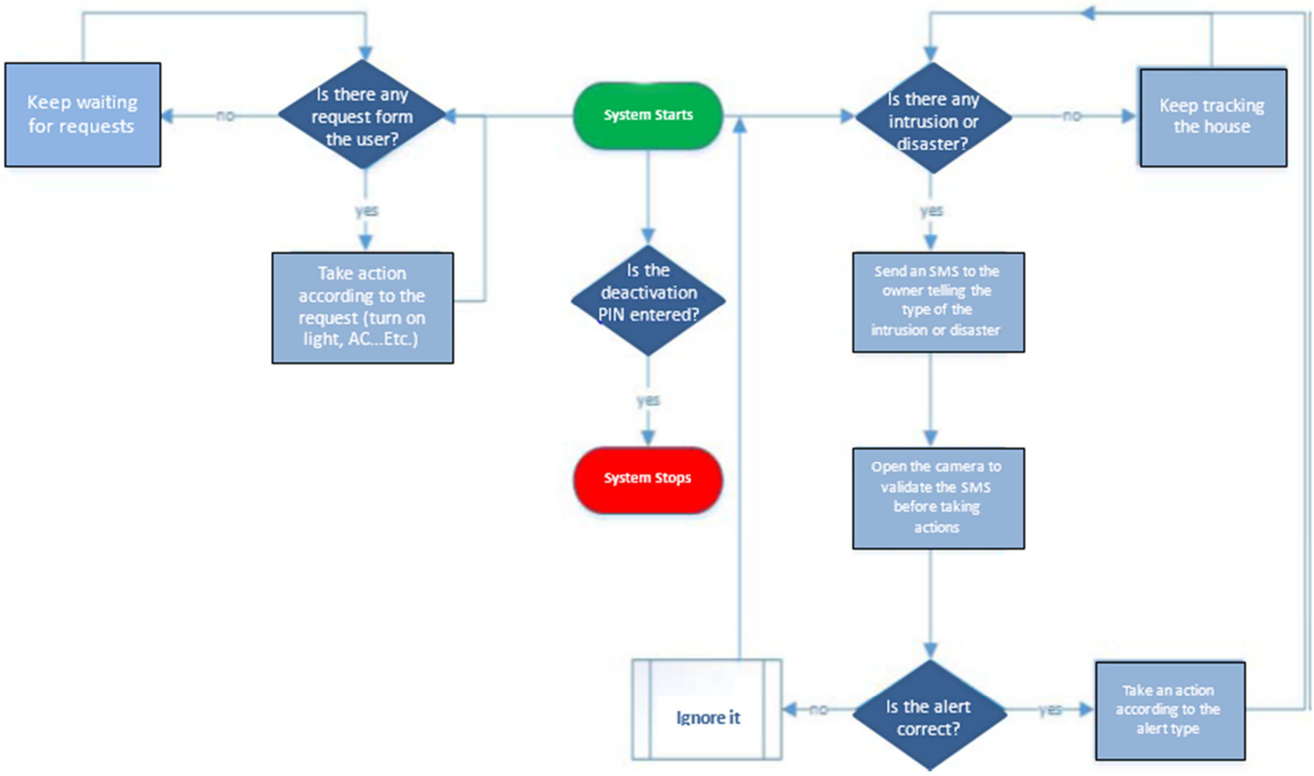

Figure 1. *Flow chart of the system in [7].*

In the event of a positive alert, appropriate actions are implemented. If the alert is negative, the system disregards it and continues to function until the user enters the deactivation PIN. At this point, the sensing parts of the system are deactivated, and only the actuating parts remain active. [7].

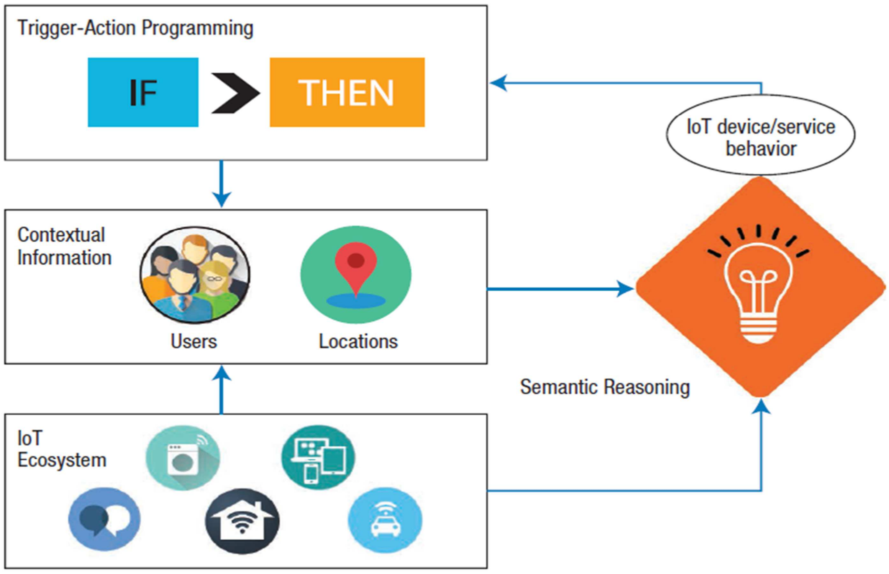

Figure 2. *EUPont is structured as an ontology with four main blocks. [6].*

With the rise of the Internet of Things (IoT), individuals, both with and without programming skills, are seeking ways to customize the behavior of IoT devices according to their specific requirements. As a result, programming environments designed for end-user development (EUD), such as IFTTT (ifttt.com), are becoming increasingly popular. These platforms enable users to create simple IoT applications through the use of trigger-action rules, where an action is automatically executed when a specific event (the trigger) is detected.

EUPont, being primarily focused on assisting end users in composing IoT applications, consists of four main blocks: Trigger-Action Programming, Contextual Information, IoT Ecosystem, and Semantic Reasoning, as illustrated in Figure 2. The Trigger-Action Programming block allows users to define abstract trigger-action rules that are independent of specific technologies or brands. Triggers and actions are organized hierarchically to provide users with choices at different levels of abstraction. EUPont offers two main levels of abstraction, namely medium and high, depending on the granularity of the user's needs.

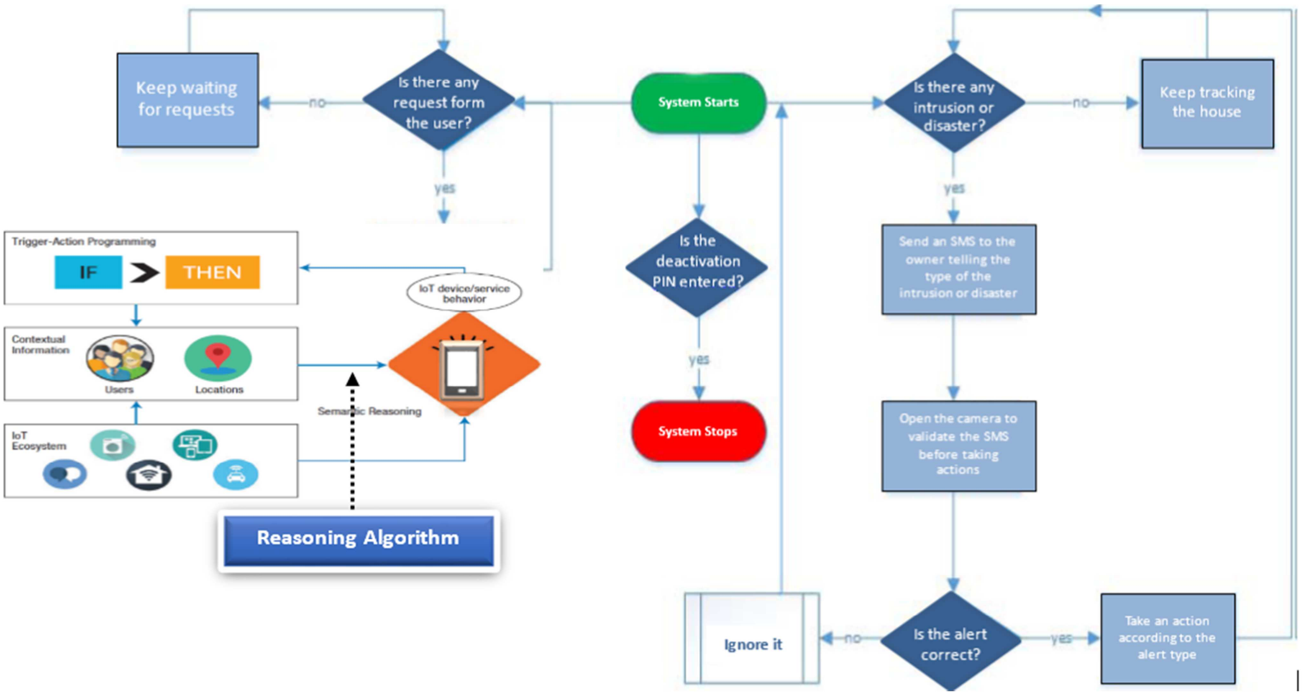

Figure 3. *The proposed used of EUPont.*

The proposed (as illustrated in figure 3) aim to improve the functionality of the system in figure 1. The enhancement begins by triggering an alert that sends an SMS to the user. To verify the alert, the user must use the camera to observe the home. If the alert is valid, an action is executed using the EUPont ontology in figure 2, instead of sending another SMS.

The EUPont ontology is a Semantic Web ontology that enables the definition of generic and technology/brand-independent trigger action rules. This ontology allows for easy adaptation to different contextual situations and as-yet-unknown IoT devices and services. The integration of Arduino with the IFTTT site can be achieved by following the steps in [17].

To summarize, the system will utilize the EUPont ontology to define generic trigger action rules. This approach will enable the system to easily adapt to new IoT devices and services, as well as improve the overall user experience.

4. Using an Algorithm to Analyze Alarm Signs and Provide Suitable Treatment

In this section, we present an algorithm -simulate, which is similar to the one described in [18]. This algorithm serves two purposes: (1) assisting the user in diagnosing the device's condition based on detected vital signs and (2) providing the appropriate treatment. Initially, data is collected from the devices and stored in the EUPont ontology. The next step involves verifying the validity of this data to ensure the proper functioning of the connected object. Subsequently, the algorithm checks the detected vital signs (such as lighting, temperature, etc.) to determine if they exceed predefined thresholds. If a threshold is exceeded, a disease diagnosis step is performed. The disease diagnosis process takes into account the measured values, additional information about the smart home (such as its various components), and safety information related to the user and their smart home. The algorithm then suggests an appropriate treatment for the detected issue, providing the user with details about their condition and the recommended course of action. In critical situations, such as a fire, the smart home triggers emergency response operations (e.g., contacting a fire engine) to be dispatched to a designated specialist.

Reasoning Algorithm
Input: EUPont ontology, contains smart home profile (number of room,…), smart home in safety (lighting, temperature, etc.), device Object knowledge (type of sensor or RFIDS, ID,)
Variables: (DCS) Data obtained from devices (ID, signs value, data range, timestamp, etc.)
Output: Actions (smart home alarm, service that need the alarm, etc).

1) *EUPont* $< -$*DCS*
2) Get to Rule base *{*
3) for each sensor or RFIDS identification do *{*
4) if (*validity*(*signs_value*) =*true*) then
5) if (*signs _ value* > *its − Maxthreshold*) *or* (*signs _ value* < *its−Minthreshold*) then
6) Retrieve, contains smart home profile (any part of home..)
7) Retrieve smart home in safety (lighting, temperature, safety,… etc.)
8) Diagnose *alarm*
9) Determine the appropriate service for alarm
10) if *alarm−needs−treatment –service* then
11) Alert smart home with treatment
12) end if
13) if *alarm −needs−manual−service* then
14) Alert user with manual service (used SMS service, EUPont service, etc.)
15) end if
16) end if
17) else Alert user to regulate the state of Object end if

5. Conclusion

In the field of smart home, the utilization of the EUPont ontology is advocated to enhance response times, as discussed in [7]. Additionally, this paper proposes the integration of Arduino devices with the EUPont ontology, aiming to assist end users in creating IoT applications.

To improve the decision-making process, a Reasoning algorithm is introduced in this study to analyze detected alarm signals and determine appropriate treatments. The integration of this algorithm with EUPont proves to be more efficient compared to using EUPont alone, as it aids in decision-making. By combining EUPont with the Reasoning algorithm, the user's interaction with smart home devices becomes more seamless, thereby facilitating the utilization of IoT.

We are planning to definition of several SWRL rules, which are classified into two distinct categories based on their primary objectives: (i) validating the accuracy of acquired vital signs, and (ii) assisting the user in alarm diagnosis and decision-making processes.

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Conflicts of Interest

The author declares no conflicts of interest.

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