10-23-2011

Demonstration: SECURE - Semantics Empowered resCUe Environment

Pratikkumar Desai
Wright State University - Main Campus

Cory Andrew Henson
Wright State University - Main Campus

Pramod Anantharam
Wright State University - Main Campus

Amit P. Sheth
Wright State University - Main Campus, amit@sc.edu

Demonstration: SECURE -- Semantics Empowered resCUe Environment

Pratikkumar Desai, Cory Henson, Pramod Anatharam, Amit Sheth

Kno.e.sis – Ohio Center of Excellence in Knowledge-enabled Computing,
Department of Computer Science and Engineering, Wright State University,
Dayton, OH 45435, USA
{pratik, cory, pramod, amit}@knoesis.org

Abstract. This paper demonstrates a Semantic Web enabled system for collecting and processing sensor data within a rescue environment. The real-time system collects heterogeneous raw sensor data from rescue robots through a wireless sensor network. The raw sensor data is converted to RDF using the Semantic Sensor Network (SSN) ontology and further processed to generate abstractions used for event detection in emergency scenarios.

Keywords: Semantic Sensor Web, abstraction, sensor, robotics, rescue environment, wireless sensor network

1 INTRODUCTION

Robots equipped with multiple heterogeneous sensors are quickly becoming an invaluable resource in emergencies and disaster scenarios [1]. They enable monitoring of the environment without unnecessarily risking the lives of first-responders. However, the avalanche of low-level sensor data generated by these robot sensors can quickly overwhelm the operator or decision-maker who is attempting to assess the situation. In this scenario, semantics can play a key role in interpreting the low-level sensor data and provide effective abstractions as a more intuitive representation of the situation; thus enabling the operator to make timely and effective decisions. In this paper, we describe a demonstration system that has a robot equipped with a temperature sensor, infrared sensor, and various gas sensors, such as carbon dioxide, carbon monoxide, methane, and compressed natural gas. With the help of Semantic Web technologies and domain-specific background knowledge, various different types of fires are detected, which will lead to different appropriate responses.

2 SYSTEM ARCHITECTURE

The purpose of SECURE is to detect fires of different classes –Class A (Ordinary combustibles), Class B (Flammable liquids), and Class C (Flammable Gases), etc. – within a building, utilizing sensor equipped robots. The detection of different types of fire can help the rescue workers to decide upon a proper response to the disaster. For example, different types of fires are extinguished differently depending on the composition of the combustible material.

Towards this goal, the SECURE system architecture is divided into four phases (as shown in Figure 1): (1) sensor data collection, (2) conversion of sensor observations to RDF, (3) analysis of sensor observations to generate abstractions, and (4) access through a graphical user interface.

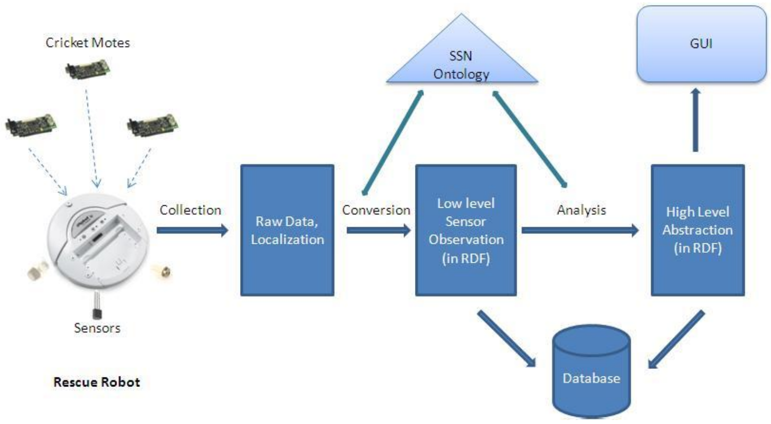

Figure 1. System Architecture

2.1 Sensor Data Collection

The sensor system consists of a wireless sensor network using Cricket motes [2] and a rescue robot equipped with environmental sensors. The cricket motes are deployed within the building, and use a combination of Time Difference of Arrival (TDoA) and multilitration for indoor location estimation [3]. The rescue robot is equipped with temperature sensors, infrared sensors, various gas sensors, and a cricket mote to provide location information.

2.2 Conversion of Sensor Observation to RDF

Data from the environmental sensors and indoor location information obtained from the cricket motes is continuously collected and streamed to a processing server. The raw sensor data is then converted to Resource Description Framework (RDF) [4] format using the OWLAPI[1] and Semantic Sensor Network (SSN) ontology [5].

2.3 Analysis of Sensor Observations to Generate Abstractions

Utilizing background knowledge which relates observable phenomena to different types of fires (encoded in a domain-specific ontology), the sensor observations are analyzed to determine the occurring fire event [6]. In this case, an abstraction is a record of the type of fire event; these abstractions are also encoded in RDF. The

[1] http://owlapi.sourceforge.net/

processed high-level abstractions will be used for situation awareness and decision making.

2.4 System Interface

The finalized results will be demonstrated using a simple GUI that will show to an operator the type of fire detected within a simulated environment. In addition, all the RDF data is published as Linked Data [7] and accessible through a SPARQL [8] endpoint.

3 DEMONSTRATION DESCRIPTION

As described in the Figure 2, the potential scenario includes a building structure with various chemicals stored in different rooms. Due to an accident, the building catches fire while the source of the fire is unknown to the first responders. The workshop demonstration will involve a simplified version of the scenario shown in Figure 2, with live-video of a robot carrying variety of sensors described above, and sensing a fire within a building, and in real-time, updating a GUI with the sensor readings and event detection, specifically the type of fire. Due to the challenge of creating various types of fire inside building, the simplified goal of the demonstration will be to differentiate sources of heat such as a candle, a butane stove or portable heater with the location information.

4 CONCLUSION

SECURE provides a layered approach for event detection in emergency scenarios to avoid information overload and improved decision-making for the emergency response operators. Figure 2 illustrates an example scenario where various types of chemicals are stored in a building, and there is a fire of unknown type. To deal with such a situation, the system consists of a rescue robot equipped with heterogeneous sensors and assisted with a wireless sensor network based indoor location system. The raw sensor data is processed using SSN ontology and background knowledge to convert the raw data to actionable abstractions representing a more intuitive representation of the situation.

REFERENCE

[1] Albert K., Henry Y.K., Robot Assisted Emergency search and Rescue System with a Wireless Sensor Network, International Journal of Advanced Science and Technolgy, 2009.
[2] Nissanka B. Priyantha, Anit Chakraborty, Hari Balakrishnan,The Cricket Location Support System, Proc. 6th ACM MOBICOM, Boston, MA, August 2000.
[3] P. Desai., Localization and Surveillance using Wireless Sensor Network and Pan/Tilt Camera, M.S. Thesis, Department of Electrical Engineering,Wright State University, 2009.

[4] Manola, F., and Miller, E. (2004). RDF Primer. (Frank Manola & Eric Miller, Eds.) W3C Recommendation (Vol. 10, pp. 1-107). W3C.
[5] Lefort, L., Henson, C., Taylor, K., Barnaghi, P., Compton, M., Corcho, O., Garcia-Castro, R., Graybeal, J., Herzog, A., Janowicz, K., Neuhaus, H., Nikolov, A., and Page, K.: Semantic Sensor Network XG Final Report, W3C Incubator Group Report (2011). Available at http://www.w3.org/2005/Incubator/ssn/XGR-ssn/
[6] Henson, C., Thirunarayan, K., Sheth, A., and Hitzler, P. Representation of Parsimonious Covering Theory in OWL-DL. In: Proceedings of the 8th International Workshop on OWL: Experiences and Directions (OWLED 2011), San Francisco, CA, United States, June 5-6, 2011.
[7] Bizer, C., Heath, T., and Berners-Lee, T.. Linked Data - The Story So Far. International Journal on Semantic Web and Information Systems, 5(3), 1-22. Elsevier. 2009. doi: 10.4018/jswis.2009081901.
[8] Prud'hommeaux, E., and Seaborne, A. (2008). SPARQL Query Language for RDF. (E. Prud'hommeaux and A. Seaborne, Eds.) W3C Recommendation. W3C.

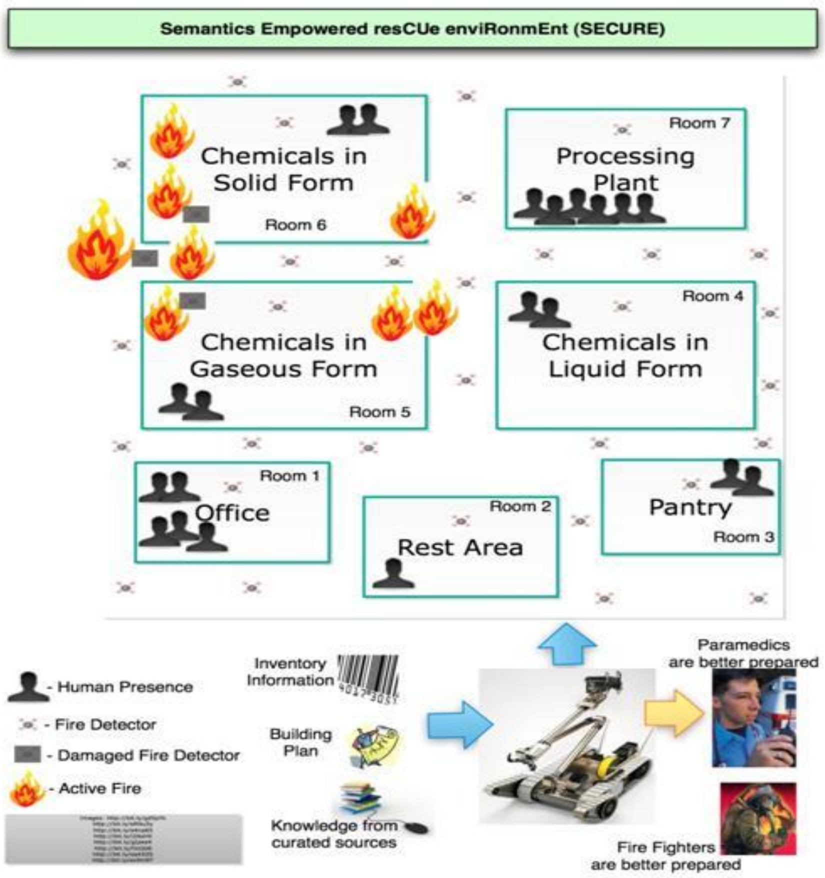

Figure 2. Example emergency scenario