SHARE-ODS: An Ontology Data Service for Search and Rescue Operations

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Abstract. This paper describes an ontology data service (ODS) for supporting Search and Rescue (SaR) operations. The ontological model represents various aspects of the command, communication, and organisational structure of the SaR forces and the deployment and progress of a SaR operation. Furthermore, the ontology supports the semantic indexing of multimedia documents in the context of SaR processes and activities. This ODS supports a semantically-enhanced information and communication system for SaR forces. Modelling the spatio-temporal aspects of an operation in alignment with possibly-unreliable information automatically extracted from multimedia objects, introduces a number of challenges for the field of knowledge representation and reasoning.

1 Introduction

Search-and-rescue (SaR) operations are conducted by fire-brigade, rescue and medical units, operating under a complex unified command-and-communications structure. The communication channels of the emergency units are push-to-talk walkie-talkies and short hand-written message forms read over the radio. All status information necessary to decision making is processed manually.

The SHARE project[1] develops a Push-To-Share (PTS) advanced mobile service that provides communication support for emergency teams during SaR operations. We present here the SHARE Ontology Data Service (SHARE-ODS), which supports the PTS service with (quantitatively but also qualitatively) enhanced information, necessary for the decision-making process at all command levels of the operation. Furthermore, the information stored in the ODS serves as a complete log of the operation for the purposes of planning and evaluation.

Although several multimedia semantic modelling and spatio-temporal modelling ontologies have been proposed, there is no unifying approach of the two. Here we propose a model for the semantic indexing of multimedia objects in the context of processes and activities. This model not only unifies these two aspects of a SaR operation, but it also allows for the semantic cross-checking of possibly-unreliable information automatically extracted from multimedia objects.

[1] SHARE: Mobile Support for Rescue Forces, Integrating Multiple Modes of Interaction, IST-funded project, URL: http://www.ist-share.org/

G. Antoniou et al. (Eds.): SETN 2006, LNAI 3955, pp. 525–528, 2006.

Due to space limitations, the overview of the state-of-the-art and the description of SHARE-ODS is very concise. For a fuller overview and SHARE-ODS description, please see technical report DEMO-2006-1.[2]

2 Related Ontologies

Ontological resources that are relevant to our SaR ontology are both general purpose ontologies and related domain ontologies.

Various general-purpose space, time, and spatio-temporal ontologies have been proposed, generally speaking as part of a more complete concept and interface specification that aims to enhance interoperability between databases and applications that make geographic and temporal references. Most prominently:

- The Standard Upper Ontology Working Group of IEEE.
- ISO geo-reference standards 19107:2003, 19115:2003 and 14825:2004. ISO 19108:2002 standardises temporal characteristics of geographic information.
- The OpenGIS specification of the Open Geospatial Consortium[3].
- Temporal ontologies, e.g. OWL-Time[4] and OWL-S[5].

Domain ontologies and task ontologies describe the vocabulary for a generic domain, task, or activity by means of specialised terms. They can be used as a basis which can be expanded and specified into an application-specific ontology. Ontologies and projects that are related to the SHARE ontology include:

- The OntoWeb[6] and KnowledgeWeb[7] thematic networks, developing standards, infrastructure and ontologies for semantic annotation.
- The aceMedia project[8] on knowledge discovery from multimedia data and ontology-driven meta-data extraction.
- The Enterprise Ontology[9], capturing the structure and processes of large corporations with complex structures and business plans.
- The CoSAR-TS project, researching the semantic modelling of military SaR operations. CoSAR-TS is based on the <I-N-OVA> model.[10]

3 The Search-and-Rescue Ontology Data Service

Search-and-rescue operations (SaR) are conducted by fire-brigade, rescue and medical units, operating under a unified command-and-communications structure. Emergency forces use half-duplex channel walkie-talkie technology for simple push-to-talk voice communication. Furthermore they exchange hand-written

[2] http://www.iit.demokritos.gr/~konstant/dload/Pubs/demo-2006-1.pdf
[3] http://www.opengeospatial.org/
[4] http://www.isi.edu/~pan/OWL-Time.html
[5] http://www.daml.org/services/owl-s/
[6] http://www.ontoweb.org/
[7] http://knowledgeweb.semanticweb.org/
[8] http://www.acemedia.org/
[9] http://www.aiai.ed.ac.uk/project/enterprise/enterprise/ontology.html
[10] http://www.aiai.ed.ac.uk/project/{cosar-ts/index.html,oplan/inova.html}

message forms that are typically read over the radio. All status information, reporting and documentation for decision making is processed manually.

SHARE proposes replacing walkie-talkies and written message forms with a push-to-share (PTS) system that supports the transmission of audio, video and digital message forms. The new system integrates the PTS communications system with the ontologically-indexed data service, supporting the decision-making process by making all relevant information and documents easily retrievable by means of semantic indexing and searching.

3.1 SaR Operations

Emergency units participating in SaR operations, operate under a unified command and communications structure and are deployed in sections (B-Level deployments) and subsections (C-Level deployments). Deployments have three aspects: (a) operational, e.g. fire-fighting, first-aid, water supply, etc., (b) geographical, that is, the area they are responsible for, and (c) operation structural, defining command and communications channels. In addition to the B and C-Level units, the operation establishes (on site) an A-Level command and control centre, which is in charge of the whole operation.

3.2 The Ontology Data Service

The SHARE Ontology Data Service (ODS) is an intelligent storage, indexing and retrieval mechanism for (a) meta-data of documents created and transmitted during an operation, (b) spatio-temporal information pertaining to the operation, and (c) information regarding the structure of the operation. This information is accessed through the ODS interface, which offers functions for populating and querying an application-specific ontology through a Web Service (complying to the W3C SOAP[11] messaging recommendation). The web service uses Protégé[12] to manipulate the OWL representation of the ontology, and a reasoning engine (currently Jena[13]) to provide the back-end for the querying functionality, allowing for the retrieval of implicit (inferred) knowledge.

3.3 Ontological Model

The ontological model of the operation is organised into three sub-ontologies: *SaR, multimedia* and *event*. In addition, there are two auxiliary sub-ontologies (*time* and *space*) that represent spatio-temporal references and actual geographical features (buildings, streets, etc) present at the theatre of the operation.

The SaR ontology holds the concepts that are related to the Search and Rescue operation, the personnel involved, and the communications system. SaR concepts include deployment types (e.g. A-, B- or C-Level), operational rôles and actual personnel, units, vehicles, equipment, etc. Deployments comprise units

[11] `http://www.w3.org/TR/2003/REC-soap12-part0-20030624/`
[12] `http://protege.stanford.edu/`
[13] `http://jena.sourceforge.net/`

and are linked together in a partology, and also connected to operational rôles their require (e.g. deployment leader, dispatcher, etc) which, in their turn, are connected to the actual personnel members that fulfil each rôle.

The Multimedia conceptual model holds meta-data from all documents (text messages, audio, video, and infrared video) generated and transmitted during the operation. This meta-data includes 'logistical' information (creation time, session the document was transmitted in, sender and recipient, etc) and content meta-data extracted automatically by image, speech, and text processing systems.

Finally, events relate a temporal instance with some characteristic or instance of the operation. Action events, in particular, relate temporal instances with an agent (e.g. a PTS_User instance), an object (e.g. a PTS_Session), and other action-specific properties (e.g., for session participation events, floor time).

4 Future Plans

We propose an ontological model that unifies SaR operation modelling with semantic annotation of documents, to offer an integrated model for an operation and all documents pertaining to it. Furthermore, we are putting together a set of tools for using the ontology at an actual SaR operation. These tools include the Ontology Data Server for updating and accessing the semantic data and the reasoning facilities that will augment the original data with inferred facts.

As a SaR operation unfolds, the ontology gets populated by various sources, some reliable (e.g. GPS) and some not (e.g. information extraction modules). Faulty data can be caught (and, possibly, corrected) when create inconsistencies, which can be resolved in favour of the more reliable source. In this manner, feedback can also be provided to the module responsible for the error, so that it can improve its performance over time. In cases where multiple sources corroborate towards accepting or rejecting multiple pieces of information, the problem of deciding which to accept as most reliable (and, inversely, distribution of responsibility in order to provide feedback) becomes a non-trivial problem. This problem has been approached in various domains, but not in the domain of responsibility distribution among multiple information extraction sources.

The other interesting direction we plan to pursue is spatio-temporal representation and reasoning for the purposes of operation planning and evaluation. At this point, the ontology models only the current situation, with a limited temporal Event ontology. In order to represent the operation through time, the Event ontology will be expanded. The temporal information will be used by a reasoning engine that supports spatio-temporal reasoning. Spatio-temporal reasoning applies to cases where we don't have precise, quantitative information about space and time, but only qualitative relationships between instances. Constraint-satisfaction spatio-temporal reasoning can be applied in these cases in order to effectively query the Knowledge Base.