A Prototype Systems Architecture for Coalition Situational Understanding

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Abstract—**The implementation presented in this work forms a prototype of a conceptual architecture that addresses the key concerns within Coalition Situational Understanding (CSU). Specifically in this demo, we summaries a suitable scenario that requires a CSU approach, we showcase the architectural principles and techniques used to bring together an array of services from the various research collaborators and we present the early successes of comparing two distinct approaches used by the overall system to pass low level information from data sources upward to support higher level CSU.**

I. Scenario

In recent DAIS ITA research [1], we have investigated the problem of traffic congestion identification as a suitable challenge in which to conduct experiments to further solutions towards Coalition Situational Understanding (CSU). Furthermore, we have proposed a conceptual system architecture for addressing five core aspects [2] of CSU. This demo concerns a prototype implementation of this architecture and highlights current and future ways that it will be used to conduct experiments furthering the art of CSU.

The scenario of detecting congestion has been chosen as we believe that in a typical city, not all data relevant to transport network congestion information is available from a single unified source, and that different organizations in the city (e.g. the weather office, the police force, the general public, etc) have their own sensors which can provide information potentially relevant to the traffic congestion problem.

With these distributed sources, we aim to use services developed by various researchers within Project 6 to answer questions about the level of congestion at particular points in London. Ultimately, the system will use knowledge-based reasoning to answer more complex questions concerning the traffic levels for a full journey from one point in the city to another.

It is worth noting that although the problem of identifying congestion could be considered to be a solved problem, it is often solved by purpose built and purposely placed sensors and systems at significant expense, time and effort. Our approach looks to bring together more multi-purpose services and data sources to gain an understanding of the relevant parts of the situation in a highly agile and cost-effective manner. Additionally, because we can access many of the pre-existing solutions to the problem (such as google maps), we can use them as a baseline for our experiments which will help us draw conclusions about our observed results in contrast to that baseline. So, concretely, our aim is not to solve the congestion problem, merely to use it as a suitable platform for investigating approaches towards supporting the CSU problem.

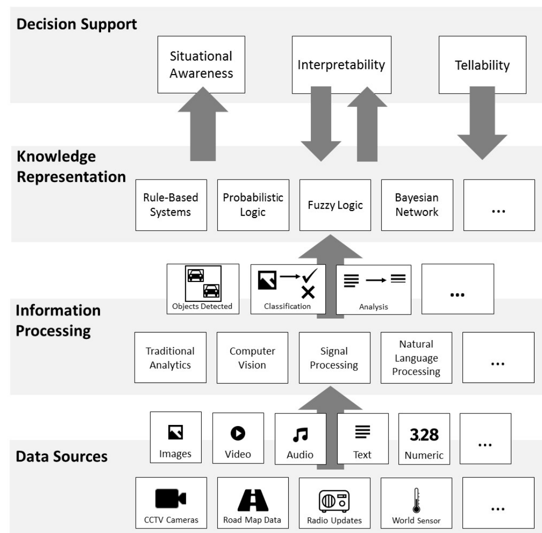

Fig. 1. Proposed High Level Architecture

II. System Architecture

The conceptual architecture is shown in Figure 1. Data is collected by individual coalition partners and transformed into more contextually relevant information before being shared and fused as knowledge in order to support final decision makers for CSU. This requires interpretability of the represented knowledge, and those models need to have the potential to accept additional knowledge from the users. We call this "*tellability*", and this human-machine interaction style can be a key element for addressing issues with sparse data.
Within this specific implementation (Figure 2), there are two processing paths utilised to provide decision support. In the first, a shorter chain of source-to-classifier-to-decision-support is used. In the second, a more complex orchestration of services provides low-level to high-level information fusion.

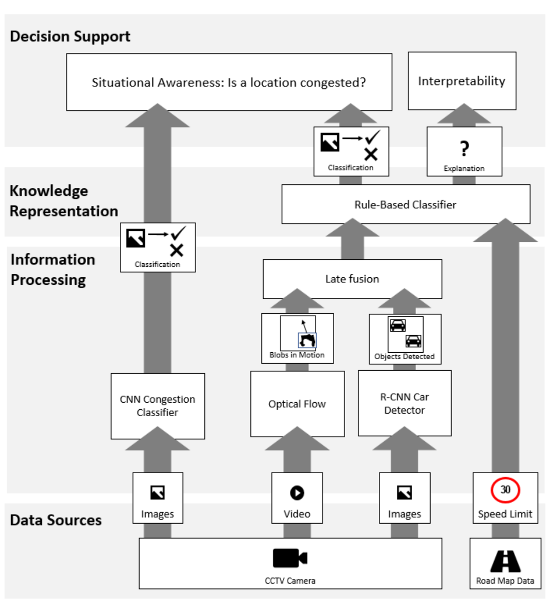

Fig. 2. Implementation Architecture

Whilst this method is less accurate than the deep learning classifier, it allows for interpretability.This comes in the form of post-hoc justification[3] rather than deep interpretability, as such further research to evaluate advantages of the two methods, as well as the quality of the provided justification through decision games is a key element of proposed future research of Project 6.

III. Key Outcomes

The implementation so far has served a key research purpose: To develop our grasp of two key areas of the CSU problem.

Firstly, it has set the foundations for easy composition of prototype distributed systems. In particular, we have established a method for chaining together independently written coalition services and created a paradigm for adding semantics to information generated by those services. Node-RED [4] has proved to be a useful existing Open Source technology in this regard by offering an easy way to outline the system architecture, process service output and visualise the flow of information. Having the ability to build these prototype distributed systems very rapidly will be key for exploring many facets of the CSU problem as part of our future work.

Secondly, within this implementation we have tested a system architecture that facilitates low-to-high level reasoning. At the low level, cars are detected in key frames of CCTV video by a RCNN and "blobs in motion" are detected in the video using optical flow. These two pieces of information are fused higher up within the service stack to form detected "cars in motion". At the next level up a rule-based reasoning service determines whether the location from the video is congested based on the level of car movement relative to the speed limit. Finally, the knowledge gained from the rule-based service classifications forms a series of congestion ratings across a defined route which can determine whether a journey will be subject to delays.

IV. Future Work Using the System

As mentioned previously, this prototype will be a key asset to support us in our ongoing research. In this section, we provide a summary of some of the planned future experiments.

Following on from work conducted to develop Subjective Bayesian Networks (SBN), this platform will allow for applied usage of the model. Here, the SBN will replace the rule-based reasoning currently present and aim to provide more resilient results, especially under conditions of limited past example data.

Work taking place to explore model and system interpretability will use this prototype for comparing various interpretability techniques. One such comparison will be to assess the effectiveness of interpretability techniques of end-to-end black-box machine learning models against the overall system interpretability gained purely from using a chain of easily explainable composite services.

Exploratory work of HTMs and LSTMs will use a selection of the services present in this implementation to produce a time series of traffic volume data with the aim of predicting future levels of congestion.

V. Demo Requirements

For this demo we will require a monitor, projector and projector screen or large display. Table space for the monitor and a laptop will be needed. Finally, WiFi or Ethernet connectivity and power sockets for all equipment (max 5).

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