Multi-Agent Target Tracking using Particle Filters enhanced with Context Data

(Demonstration)

Rik Claessens,[12] Alta de Waal,[3] Pieter de Villiers,[34] Ate Penders,[25] Gregor Pavlin,[26] Karl Tuyls[15]

[1]University of Liverpool, United Kingdom
{rik.claessens, k.tuyls}@liverpool.ac.uk
[2]Thales Research & Technology, Delft, the Netherlands
{ate.penders, gregor.pavlin}@d-cis.nl
[3]University of Pretoria, South Africa
alta.dewaal@up.ac.za
[4]Council for Scientific and Industrial Research, Pretoria, South Africa
jdvilliers1@csir.co.za
[5]Delft University of Technology, the Netherlands
[6]University of Amsterdam, the Netherlands

ABSTRACT

The proposed framework for Multi-Agent Target Tracking supports *i*) tracking of objects and *ii*) search and rescue based on the fusion of very heterogeneous data. The system is based on a novel approach to fusing sensory observations, intelligence and context data (i.e. the data about the environmental conditions relevant for the tracked target).

In contrast to the traditional approaches to target tracking (e.g. maritime or aviation domains), the emphasis is on tracking with low quality data sampled at low frequencies from different sensors dispersed throughout a larger area that may be only partially covered.

In this demo we illustrate a live, real-time target tracking application that uses a Multi-Agent System approach to find and connect relevant information sources.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence - Multiagent Systems

Keywords

Distributed Information Fusion, Bayesian Networks, Particle Filters, Target Tracking, Situation & Threat Assessment

1. INTRODUCTION

Target tracking is the process of matching emerging observations to targets. The goal is to identify subsets of observations that originate from the same target in order to determine the current location of each target. Typically, target tracking deals with sensors such as radar, sonar or infra-red sensors. However, in some domains like search & rescue, area protection of wildlife preservation, these type of sensors are often unavailable. Instead, authorities that need to track down a target rely on incoming information that might be of low quality, low frequency and disparate in nature. Furthermore, these sensors often provide only partial coverage of the area of interest.

Another challenge in these domains is the fact that the constellation of human operators, sensors or algorithms that can be deployed might not be known prior to the operation. Therefore, authorities require a system that allows plug & play functionality of agents that each provide a capability.

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2. SYSTEM OVERVIEW

The tracking system is designed to control the information discovery and information management between data producers and data consumers (e.g. a UAV camera feed being sent to a police officer). It is based on a technology called Dynamic Process Integration Framework (DPIF) [5]. By using DPIF, different agents specify a capability that they are able to provide to the system and what types of input they require to perform this capability. These agents can either be human operators or automated processes (algorithms or sensors). For instance, an intelligence analyst provides a text mining capability or a camera system provides a license plate recognition capability. Finally, a tracking agent takes as input any observation of the target that needs to be tracked, i.e. input from any agent that provides the capability of observing a target.

The tracking is done by using a Particle Filter (PF) algorithm. A well written overview of a PF algorithm used for tracking purposes is given in [2]. To compensate for the impact of low quality of observations and partial coverage of sensors, context data (CD) about the environment can be used. This context data may include GIS data, intel on police roadblocks or flooded areas and information about the likely destination of the target. Context data (CD) is introduced in the PF algorithm as an additional update step [1].

3. DEMONSTRATION

In Figure 1 a possible configuration is shown of several agents. Here, an *operator* requires a target to be tracked and so, requests a tracking process to be started. In turn, this tracking process will require observations of the target and contextual information about the area in which the target is being tracked. Therefore, the tracking process will dynamically request any sensory information and context data for the target. Important to note here is that the target tracking process will not specifically request a specific agent to provide information, but rather request any agent that in the current context (time and location) can provide a sensing capability. Furthermore, it is also possible to keep a human operator in the loop in order to confirm that the automated software has successfully detected the target. All this information is then routed to the target tracking agent.

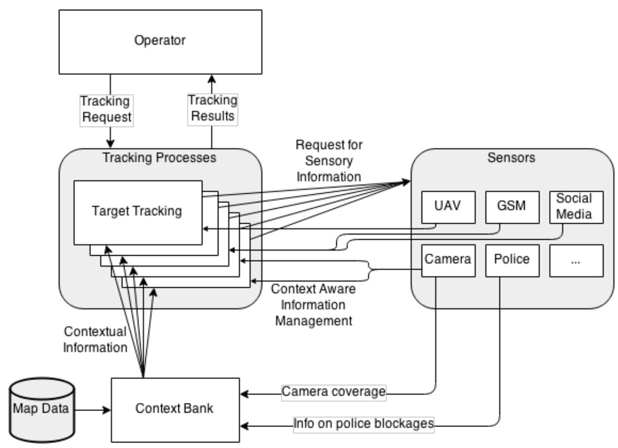

Figure 1: A possible configuration of different components that can provide information for target tracking enhanced with context data. Each rectangle represent an agent.

The system has been applied and tested in various scenarios including a wildlife preservation scenario situated in the Kruger Park in South Africa. Rhino poaching in the Kruger Park is a growing problem, mainly to the huge demand in Asian markets because of the believed healing effects rhino horn would posses [4, 3]. Because of the size of the park of almost 20,000 km^2, it is difficult to survey the complete area of interest. In this domain, the proposed system is tested on a scenario with a target that is being tracked by a static sensor (e.g. a ground radar) and a UAV flying overhead. A selection of the results is shown in Figure 2. In this scenario, the target moves outside of the range of the static sensor and at this moment, we observe a performance increase when tracking with context data in comparison with the experiment without CD. The context data in this scenario is based on the road maps of the area.

4. CONCLUSIONS

The need arises in various domains for a plug & play functionality for discovering and connecting relevant data producers and consumers. We demonstrate a tracking application running in real-time, in which several agents provide different capabilities that can be used for tracking a target. The system is designed to be a generic solutions for domains with sparse, low quality and disparate observations, such

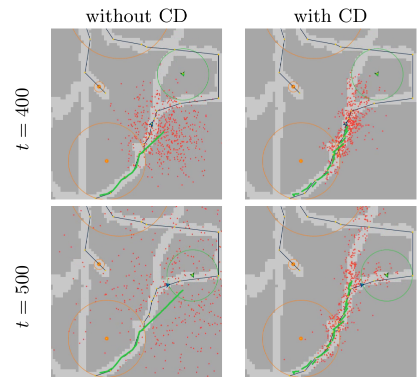

Figure 2: A selection of snapshots of the Kruger Park experiment. The target is shown in blue, its true track in dark blue, particles in red, radars and their range as orange dots and circles respectively, a UAV and its range as a green kite and circle and the expected track in green. The results are shown for tracking without and with CD respectively for times $t = 400$ and $t = 500$.

as search & rescue, patrolling, area protection and wildlife preservations. Experiments show that it is possible to compensate for low quality and low frequency observations by using context data.

Video available at:
`http://www.rikclaessens.nl/aamas2015demo/`

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