A Novel Data Fusion Architecture for Unmanned Vehicles

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Abstract. An effective functioning of unmanned vehicles demands to process large amounts of various data coming from sensors, on-board data bases etc. Therefore date fusion technology is one of key-technologies for autonomous vehicles and systems. In order to systemize such data processing special so-called data fusion architectures are used (e.g. JDL, Waterfall, Boyd etc.). However some of those have a list of restrictions w. A goal of this paper is to present a novel data fusion architecture which could be used on board of unmanned vehicles. This architecture consists of 5 basic layers: parameters identification, state identification, (object type identification), situation identification and task implementation identification. The proposed architecture has some advantages in comparison to those already in use. Author considers that presented architecture has good visibility, intuitive understanding, possibility for deep feedback usage and good potenia for automatic reconfirguration and self-learning. The developed data fusion architecture can be used for building complex data fusion systems on board of unmanned vehicles as well as of group of vehicles and even of systems of higher hierarchy.

1. Introduction

Data fusion by itself can be defined as a process of information generalization based on more than once source of information. Data fusion and sensor fusion (as its particular case) are among key-technologies towards autonomy of robots [2].

In [8] it was proposed to distinguish following cases of data fusion in Unmanned systems (figure 1):

Time-based data fusion. While tracking variation of some parameter in time sequences it becomes possible to estimate other parameters of UV. Another case of such data fusion is data filtering. For more details see [3].

Reliability-based data fusion. While fusing data from several sensors with low-reliability characteristics it becomes possible to get highly reliable information.

Location-based data fusion. By fusing information from several sensors each one with narrow working space one may get information of the large working space [7]. Another case of space-based data fusion is fusing date from dispensed sensors which gives us new information.

Sensor operating principal-based data fusion. Fusion of data from sensors measuring same parameter but functioning on various principles gives information with higher reliability factor.
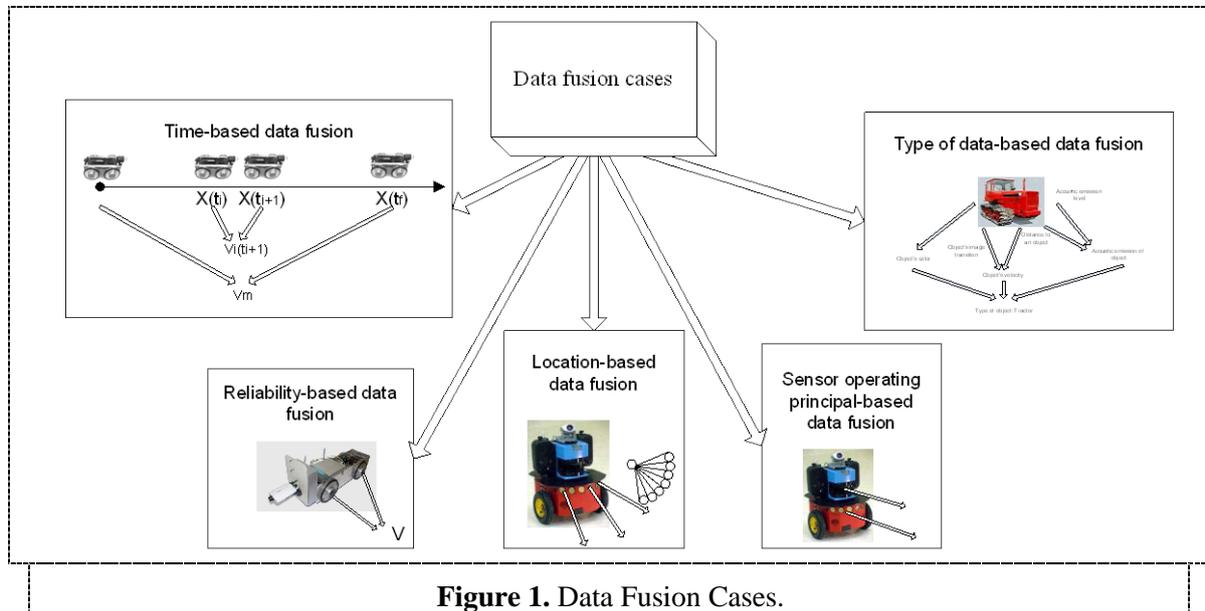

Figure 1. Data Fusion Cases.

Type of data-based data fusion. This one is used to produce information basing on data of various type (e.g. fusing information from video sensor with information from laser sensor). This type of fusion is intensively used especially for object recognition.

Analysing this classification it can be confirmed that most of the data fusion cases in unmanned systems can be described by these fusion cases or by their combination.

Modern UVs are extremely complex systems with large number of data flows [5]. In order to analyze such amount of data flow it is necessary to adjust those data flows. This is known as data fusion architectures. There exists variety of such architectures: JDL, Boyd model, LAAS, The Omnibus Model, Waterfall model and some others [7].

However according to author these architectures lack some intuitiveness, logic and flexibility.

2. Hierarchical Data Fusion Architecture

Author of this paper proposes following Hierarchical data fusion architecture (Figure 2).
Here author describes layers' term as following:

Parameter – predicate which describes as a rule quantitatively property of a single component of a UV or of environment. Input of this level usually comes directly from sensors.If you don't wish to use the Word template provided, please set the margins of your Word document as follows.

State – predicate which describes quantitatively or relatively property of a whole UV or of environment. Input for this predicate comes from parameters or from sensors directly.

Object type – generalized identification of an object present in environment, which is defined by its typical data and by its potential interaction with UV.

Situation – is a generalized notion which describes complex of interaction between robot and environment.

Tasks – a set of situations in serial-parallel order. These situations must be achieved (implemented) by robot in order for a task to be fulfilled.
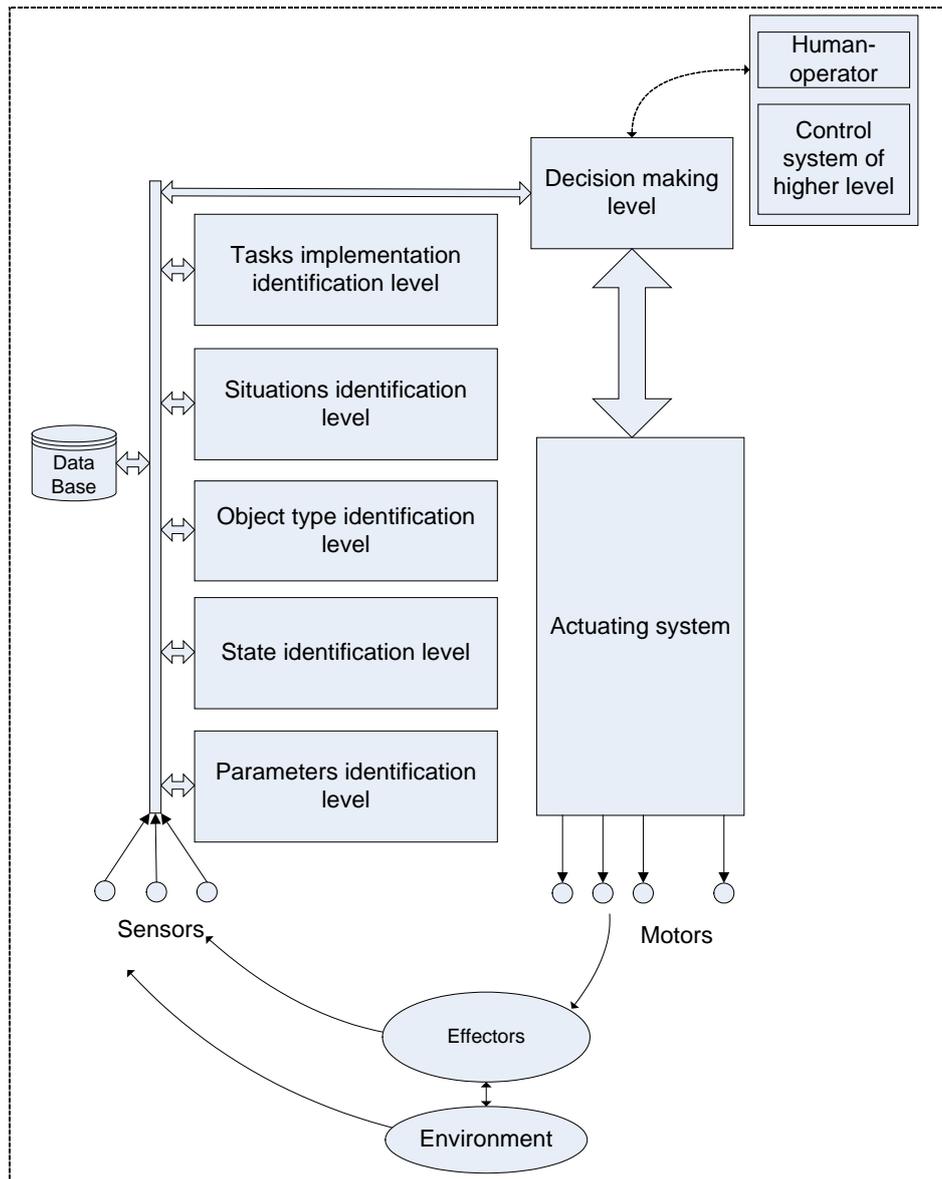

Figure 2. Hierarchical Data Fusion Architecture.

Data from various sensors of UV and of environment flows to the common bus. An important advantage of this scheme is that it can use data from both on-board and stand-alone sensors.

Usage of common data bus is also an important advantage as it allows to exchange data and information among various levels freely. As it was mentioned before data may flow to the next level

and also to higher levels directly. This also allows in case human-operator needs it to receive information on any predicate directly.

All the data is fused in bottom-up direction. However it's obvious that some more simple or primitive systems may omit some of the higher levels. However highly autonomous systems will involve all the levels. When needed extra data will be acquired from data base. Final output comes to the decision making level which sends instructions to actuators and sub-systems. It also may be built on same approach.

The proposed Hierarchical data fusion architecture has following advantages compared to other architectures:
- it reflects hierarchy of modern UVs' structure;
- it has clear demonstrable and visual properties, has a high degree of intuition for human-operator;
- this structure allows wide usage of various data flows and feedbacks including transient flows;
- this structure can be effectively implemented with modern control methods [1];
- structure's modularity allows various ready-to-use solutions be transferred from one scheme to another.

According to author's opinion proposed structure can be widely used also for automated programming of complex data fusion systems and algorithms.

Acknowledgement

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