NUTS AND BOLTS OF THE DECISION MAKING

DISCRETE EVENTS IN THE CONTINUAL WORLD

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Let us pause in the discussion of semantic storage - this is useful to take into account the questions and comments of readers in the next part.

Now let us get back to the processes of information processing by the Situation Room modules (Architecture). These modules add information to Semantic Storage, Chronicle, and Data Storage and are consumers of the information stored there. All three components of Information Storage not only store information but also act as an intermediary in the exchange of information between the modules that process information.

Making intelligent decisions about how to proceed is based on predicting the consequences of a decision. In turn, forecasting requires information of two kinds: accumulated knowledge about the environment and its own capabilities, and information about the current situation. The description of the situation again consists of information about the situation outside the controlled object and about the internal state of the controlled object.

The most significant difficulties take place in building a model of the external environment. Unlike a controlled system itself, it is not known in detail to the system designer, even in cases where the system's mission is well defined. Not only the parameters of the environment change, but also its structure - objects appear and disappear, their relative position changes, and so on. It means that in missions that require AGI, it is not possible to have an immutable predefined description of the environment. An obvious requirement is the arbitrariness of the structure of the model since the structure of the environment is unknown in advance.

The AGI requirement for human-like intelligence implies the ability to use the system in a ***physical*** environment. It has consequences that significantly affect how information about the environment is collected and processed because of an essential feature of physical environments: all ***real-world processes are continuous in time***.

At the level of experience accumulation, forecasting, and decision-making, the main object of logical manipulations in one way or another are ***discrete events*** (including actions) and chains of such events. However, in the physical environment, objects move and change in time not by jumps (like prices or movements of pieces on a virtual chess dock), rather smoothly. The quantities measured by the sensors are essentially ***continuous (and mostly smooth) functions of time***. When it comes about events in the ***discrete*** world, it is impossible to change the number of events arbitrarily - they are the root elements of the discrete environment (the act of buying or serving, getting the next character or word from a text stream, a move in Go or chess). In a physical environment, we can measure position, speed, color, temperature more or less often at our discretion, and measurements by various sensors performed asynchronously. This arbitrariness ***does not allow us to consider measurements as actual events***. In other words, time discretization is not a helpful way of moving from a continuous medium to its description (model) in terms of events; a more intelligent option is required.

Another essential aspect is that in a natural physical environment, the stable functioning of the system requires the inclusion of ***discovered but unidentified objects*** in the ***dynamic model*** of the environment. For example, if UMO (*Unidentified Moving Object*) appears in front of a car, which the control system does not identify as a car, or as a person, or as an animal, it is natural to expect reasonable actions to avoid an accident, despite the fact that the nature of the object is unclear.

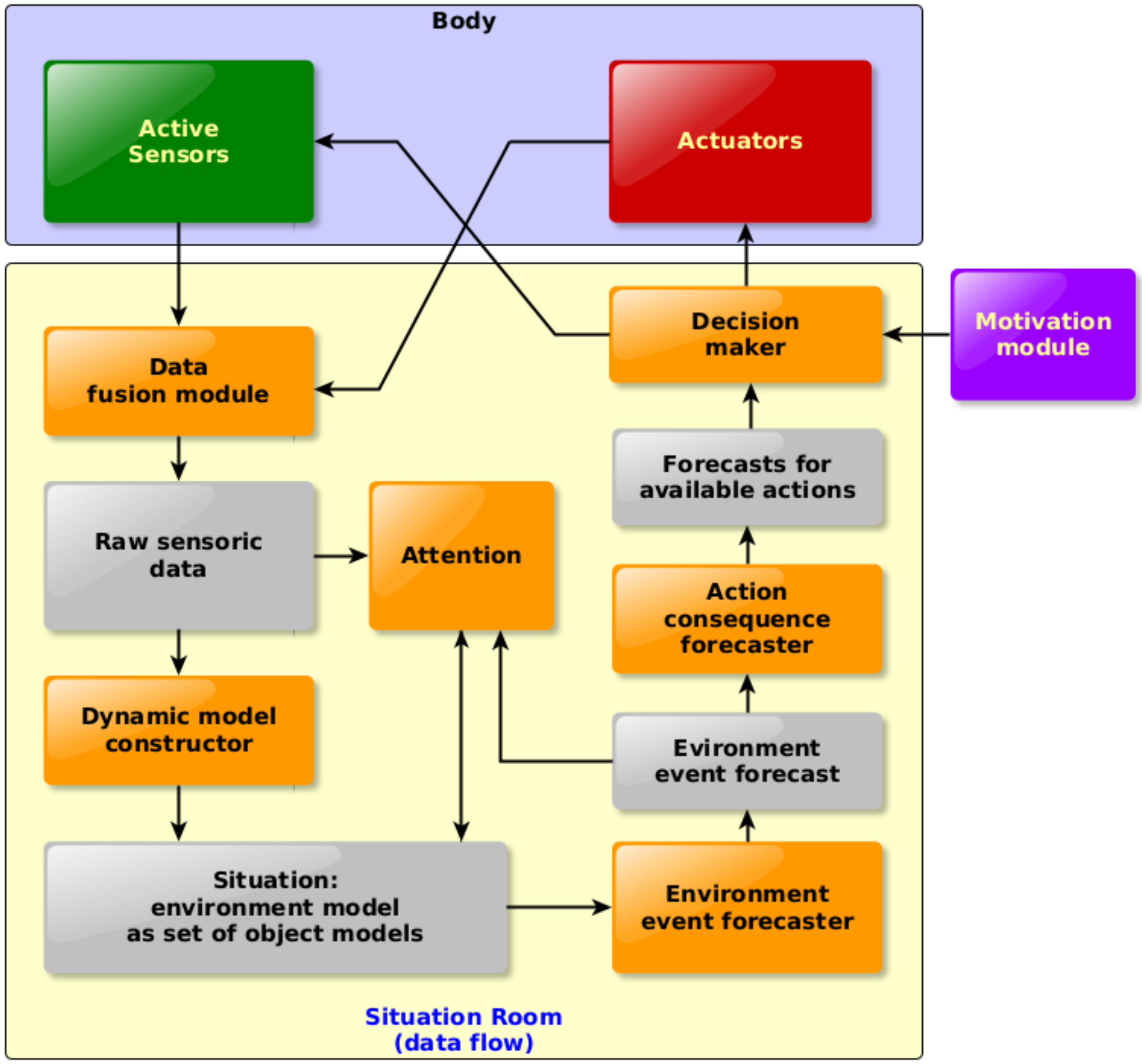
As a result, the following scheme develops: firstly, some of the events in the environment are formed by the facts of detecting new objects, by identification of discovered object (which is not always possible and may occur some time after the detection of the object), and the facts of the disappearance of objects from the observed space. Another part of the events is predicted future events, based on the analysis of the interaction of dynamic object models in the environment.

For each of the detected environmental objects, a dynamic behavior model is built, the parameters of which are determined by data from the sensors. If it is possible to identify an object and exists a specialized behavior model for this category of objects, then it is used. If the object is not identified or there is no specialized model for it, the ***default model*** is used. The parameters of the models are regularly updated (refined) as new data from the sensors arrives.

The combination of such models makes it possible to predict the interaction of objects - for example, collisions (physical or visual), the occurrence of dangerous or vice versa, favorable situations, and so on.

Thus, a necessary component is a universal default model of the dynamic of environmental objects. By dynamic, we mean a time-continuous change in parameters measured by sensors (or calculated in the prescribed manner by "smart sensors" that perform preliminary data processing). As a result, the default model comes down to the construction of ***functions that approximate the change over time***, using measurement data for a certain period, and ***extrapolating*** the data to predict the situation.

As a result, the Situation Room contains four operational datasets (shown in gray) and six modules that process information in parallel and asynchronously:



Data from sensors and actuators are accumulated and permanently updated by the ***data fusion*** module. Raw sensor data includes data and environment events if sensors record ones. Actuators are sources of information about the state of the control object (including events of system failures).

The ***dynamic model constructor*** detects objects in the environment, identifies them as much as possible, forms dynamic models of objects, and calculates their parameters (using default models for unidentified objects and specialized models for identified ones). The model update rate depends on the priority given by the ***attention*** module. The same module removes models from the set when they are no longer relevant.

The description of the situation, that is, the current set of models, implements the ***map paradigm*** with a constantly updated position and orientation of the presented objects. Updating the whole situation description may include highly complex operations like bringing the coordinates of all objects to a moving coordinate system associated with the controlled object.

Each object included in the description of the current situation can be either an atomic object or a structured one consisting of child objects. The object construction module performs the combination of objects into more complex conglomerates when it becomes possible after object identification. Identification uses both the current values of the object's parameters and the parameters of functions that approximate their change in time (thus, ***identification uses the dynamic model*** of the object).

The parameters (coefficients) of approximation of the object properties as a function of time are the ***attributes*** of the corresponding entities. De facto ***object attributes are parameterized time functions***, which are regularly updated (refined) according to the data from the sensors.

The ***environment event forecaster*** generates a potential sequence of events in the environment based on the environment model. Time naturally plays an essential role in constructing this sequence; predicted events have ***time as an attribute*** and are ordered accordingly.

The module for predicting the results of potential actions combines into one whole the possible consequences of actions of a controlled object with a forecast of events in the environment into a single multivariate forecast with a tree structure.

The forecast is constructed ***step by step, consistently increasing the forecasting horizon***. The process of constructing a forecast ends either with the achievement of the planning horizon limit (defined by the available computing resources) or making a decision. The decision-making module analyzes the forecast in parallel with the expansion of the forecasting horizon, providing the ability to quickly decide in obvious situations or, conversely, a more detailed analysis in a not obvious situation.

From the above, it is clear that the set of sensors, actuators, and possible actions significantly affect the implementation of the Situation Room modules (starting from data fusion). The ability to build a general system is ensured because the specifics of a particular controlled system and initial information about the environment in which the system should operate are stored in Semantic Storage and Data Storage and does not hard-coded.

The accumulation of information about the behavior of unidentified objects of the environment with subsequent generalization can form new categories of identifiable objects. The implementation of this type of self-learning is a topic for another chapter.

As it is clear from the above, the continuity of processes in a natural physical environment significantly affects the design of the Situation Room. AGI systems that are not designed to work in a physical environment can be based on less complex approaches that do not require continuous dynamic models of objects, but this significantly reduces the degree of universality and, accordingly, the scope of possible application.

SUMMATION

- *The parameters of objects of a natural physical environment are continual in time.*
- *Predicting the situation in the physical environment requires the use of dynamic models of objects.*
- *Dynamic models are required for both identified and discovered but unidentified objects.*
- *Dynamic models of environment objects use functions of time as attributes of entities.*
- *Approximations of values obtained from sensors in a series of sequential measurements play a role of dynamic models*
- *The lack of ability to work in a physical environment significantly narrows the scope of the AGI system*

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