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Reference Architecture of Intelligent System

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Introduction

Intelligent agents continuously perform following functions: perception of dynamic conditions in the environment; action to affect conditions in the environment; and interpreting perceptions, solve problems, draw inferences, and determine actions. Perception informs reasoning and reasoning guides action, although in some cases perception may drive action directly. This abstract definition allows for a great variety of biological and artificial agents whose capabilities range from extremely limited and stereotyped behavior to extremely sophisticated and versatile behavior [3,7].

Intelligent system consists of two parts: situation perception part, and planing – actions part.

Components of reference architecture

Any intelligent control system consist of two parts: internal (computational) and external – interface between the real world and application. The internal part can be decomposed into four modules: sensory processing, world modeling, behaviour generation and value judgement. Input to internal part of intelligent system are realized by sensors, and output – by actuators.

Output from intelligent control system is realized by actuators, that move, position arms, legs, eyes. An intelligent control system can have several or a lot of actuators. All these actuators must be coordinated to perform tasks and fulfil goals. State or space trajectory or motion is performed by actuators. Actuators are motors, pistons, valves or soleinoids. In organizational systems, actuators can be individuals or groups of people (agents).

Input to an intelligent control system is realized by sensors, which can include brightness or color sensors, force, position detectors, acoustic, vibration, smell, taste, pressure and temperature measuring devices. Sensors are used to monitor both the state of external world and the internal state of intelligent system. Sensors realize the sensory processing system. In organizational systems, sensors, like actuators, can be individuals or groups of people (agents).

Sensory input data from different sensors are fused to perception of the state of real external world. Sensory processing system compute distance, shape, orientation, surface characteristics, physical and dynamic attribute of external world objects. Sensory processing system may include elements of speech, language or music recognition. Perception of external world occurs by comparing sensory observation results with expectations generated by an internal world model.

The world model is the best estimate of the external world state, which is perceived by intelligent system. The world model includes the database of knowledge about the external world. This model also contains a simulation capability that generates exceptations and predictions. The world model generates answers to requests for information about past, present and future states of world. This information is it provided to the behaviour generation system in order to make plans of actions; to the sensory processing system in order to perform correlation, recognition of states, objects and events; to the value judgement system in order to compute values such as risk, uncertainty, importance and attractiveness.

The value judgement system determines good or bad, important or trivial, certain or improbable. It computes the probability of correctness and assign believability or uncertainty, attractivness or repulsiveness to objects, events and states of external world. The value judgement system provides the basis for decision making, actions choosing.

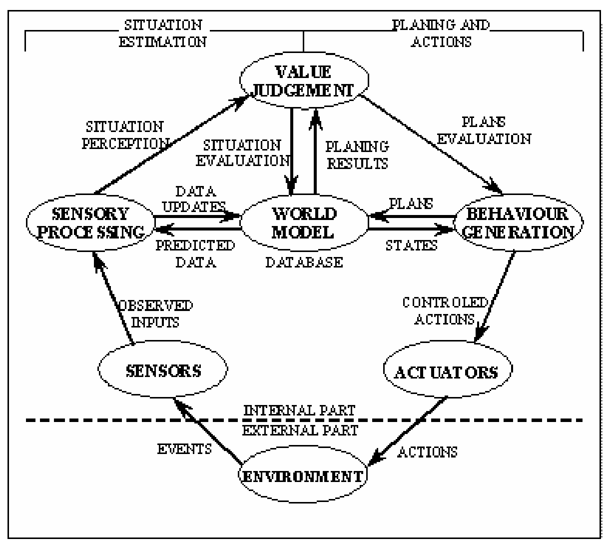

Fig 1. Functional relationship between modules

The behaviour systems selected goals, plans and execute tasks, in other words, generates behaviour. Tasks are decomposed into subtasks, and subtasks are sequenced to achieve goals. Goals are choosed and plans generated by a interaction between behaviour generation, world modeling and value judgement systems. The behaviour generating system hypothesizes plans, then world model system predicts the results of those plans, and then value judgement system evaluates those results. The behaviour generating system selects the plans with the highest evaluations. Also, behaviour generating system monitors the execution of plans and modifies existing plans when the present situation requires it [4]. All six systems (modules) interacts with each other. The architecture combining these modules is shown in figure 1. In this control system, the sensory processing system maintains an internal model of the external world. The behaviour generating system controls actuators to fulfil goals taking into account of the perceived external world.

The behaviour generating system interacts with the world model and value judgement to generate or select plans based on values such as cost, risk, utility and other priorities. The sensory processing system interacts with the world model and value judgement system to assign values to perceived entities, events and situations.

Queres and tasks status are communicated from behaviour generating module to world model. Returning information are communicated from world model back to behaviour generating module. Updates to the world model are communicated from sensory processing module to world model. Observed entities, events and situation are communicated from sensory processing module to value judgement module.

Hypothesized plans are communicated from behaviour generating module to world model. Results are communicated from world model to value judgement module. Evaluations are communicated from value judgement module back to the behaviour generating module, that hypothesized plans of actions**.**

Elementary loop of functioning

Control system of the overall actuation processes can be decomposed into a subsystems [1]. In other words, actuators of the system can be atached to the different levels of the control system hierarchy. Also, control system of the overall measurement processes can be decomposed into a subsystems, or all sensors of the system can be atached to the different levels of the control system hierarchy.

All components of the control system can be represented at different scales of time and space and each element of the control loop can be represented as a separate module.

Elementary loop of functioning with several actuators is shown in figure 1. The goal (G) goes into module (BG). module (BG) find the solution of the problem and transform into a set of several actions. This actions are transfered to the set of actuators (A). A set of sensors (P) is integrated in the control system. The external world (W) is perceived through measurements of sensors and then internal world model (WM) is updated. World model contains the external world perception. The value judgement module (VJ) selects the best sensor measurement (S), the best world model (WM) and the best problem solution in behaviour generating module (BG).

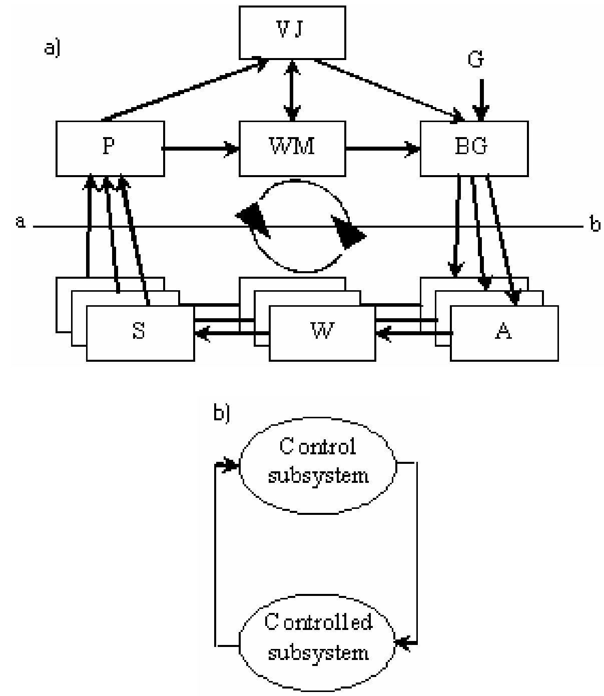

Fig 2. Elementary loop of functioning

The line *ab* separates real external world and its internal perception.

The arrows between the world model (WM) and external world (W) represent virtual communication between real world and internal world model through measurements of sensors.

If virtual perception of the real world is not completely accurate, behaviour of the system is less successful to achieve goal. Figure 2 shows elementary loop of functioning, which consists of two domains: the control system and the controlled system (see Figure 2b). The modules below line *ab* are the subsystems which are controlled. All signals from several sensors are transfered into one module P. And one module BG controls several actuators (see Figure 2a). The control and controlled subsystems are separated from each other. Each subsytem can be considered as a node of control hierarchy.

Second stage of this simple control system is elementary loop of functioning with two control levels (see figure 3a, 3b), where controlled units are jointed into groups. Every unit from the group can be considered as mashine with some actuators or sensors. This control system receives tasks or goals to overall control system and generates tasks or goals to the mashines.

Nowadays, it is divided three types of agents: simple rational agent, autonomous agent and individual agent (communities of agents, societes of agents).

Definition "rationality" is associated with the laws of thinking or laws of logic [1]. Agent is a system that has percept environment through sensors. A simple rational agent is like automated machine or pre-programmed robot.

It has simple devices for choosing one of a few preplanned solutions, can have elementary world representation and simple learning capability.

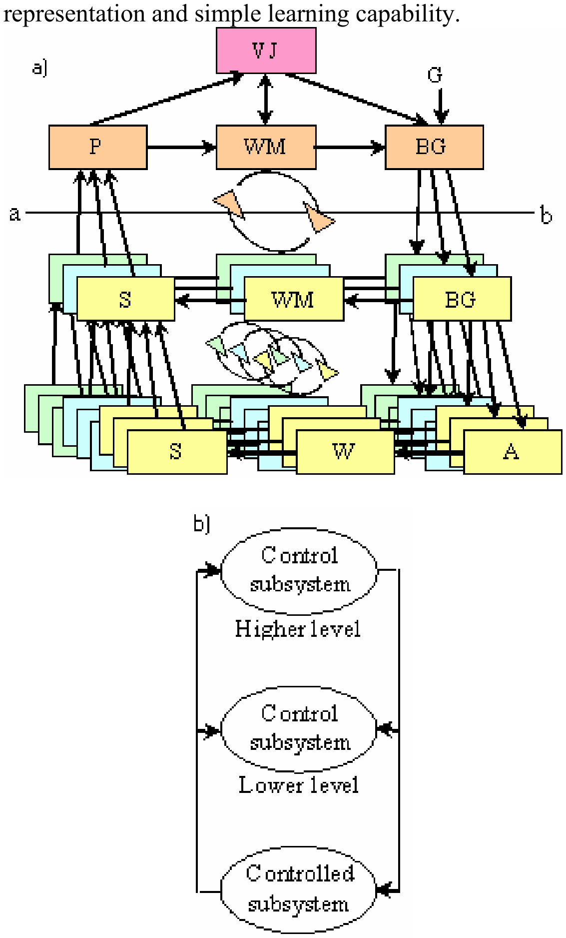

Fig 3. Elementary loop of functioning with two control levels.

All processes described for the modules of intelligent system: BG, WM, SP and VJ can be implemented in neural net or could be implemented in a biological neuronal substrate.

Modules BG, WM, SP and VJ can be implemented by functions of the form:

$$P = H(S). \tag{1}$$

Each single module can be computed by a linear function of the form:

$$p(k) = h(S) = \sum_{i=1}^{N} s(i)w(i,k), \tag{2}$$

where

$p(k)$ - output of the k-th submodule,

S - ($s(1)$, $s(2)$, ..., $s(i)$, ..., $s(N)$) is an ordered set of input variables defining an submodule input vector ,

W - ($w(1,k)$, $s(2,k)$, ..., $s(i,k)$, ..., $s(N,k)$) is an ordered set of weights connecting the N inputs to the submodule.

Their field of application is limited. In many areas rational agent is called automated device or system.

Intelligent agents

Agent based architecture consists of autonomous intelligent virtual applications or of intelligent robots. All agents are software units that have inputs and outputs, rules. A software unit is equipped with devices for interaction with a simulated world or with the real world. Intelligent agents are computational entities that produce their behaviour depending on benefits to achieve goals [4,5].

Intelligent agent is equipped with tool of self-reorganization and learning, can deal with situation. Agents are jointed into interactive and communicative network, so the sets of agents joint into coalitions of agents.

Agents can be of folowing types: a) simple agent - a simple input-output unit with the fixed number of IF-THEN rules and single alternative of actions; b) simple agent with selector - a simple input-output unit with the fixed number of IF-THEN rules and the ability to select from a list of the alternatives of actions, which need to select one; c) simple agent with combiner - a simple input-output unit with the fixed number of IF-THEN rules and the ability to select and make various sequences of alternative actions. Agents can be equipped with a capability to learn its experience, then generate additional rules and add them to its database.

Automated system work without external intervention of human. This autonomy is limited, because it is known in advance what and when will happen if states of environment changes. The term autonomous is used when the future situation is not known and the agent has freedom to decide what, when and how to behave. Agents behaviour is determined by its own experience [1].

Software agents that can change their location in the system are called mobile agents. They can travel across a network and perform tasks on machines. This allows processes to migrate from computer to computer [2,3].

Groups of agents behave as agents too and can be called new agent as generalized agent. And this agent can also be a part of new group of agents. Each generalization gives a new scale of system resolution. Such grouping of agents can be interpreted as merging of multiple agents into groups (first level), groups into communities (second level) and communities into a society (third level). Each agent consists of agents of higher resolution.

Conclusions

The architecture of intelligent control system is introduced in this works. Intelligent systems represent increment in behavioral requirements compared to typical control systems. Typical control systems as we know them today, have their intrinsic architecture and are limited and can only function as menial computational tools. However, machines have an untiring ability to process numbers. If we can find a way to map abstract concepts into numbers then perhaps machine could rise a step or two on the intellectual scale and provide us with the sought after capability of becoming these somewhat intelligent assistants [4, 6].

Intelligent systems can be realized in many real applications (e.g., intelligent monitoring systems, intelligent surveillance systems, intelligent associate systems). Agents that function effectively in these areas would have real practical utility. In comparison with the traditional approaches, the agent-based approach presents important improvements such as expansibility, robustness, reactivity, support to distributed environments and re-use of the application code [8].

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V. Teresius. Intelektualiųjų sistemų bazinė architektūra // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2005. – Nr. 7(63). – P.53–56.

Intelektualūs agentai nenutrūkstamai atlieka šias funkcijas: besikeičiančios aplinkos būsenų suvokimo, atitinkamo sureagavimo ir poveikio aplinkai, išorinės aplinkos interpretavimo, užduočių sprendimo. Pateikiama intelektualiosios valdymo sistemos architektūra, jos pagrindinės dalys bei tų dalių tarpusavio ryšiai. Intelektualiąją sistemą galima suskaidyti į vidinę ir išorinę dalis, sąsają tarp išorinės aplinkos ir programos (aplikacijos). Vidinę dalį dar galima būtų suskaidyti į keturis modulius: daviklių duomenų apdirbimo, pasaulio modeliavimo, veiksmų generavimo ir verčių nustatymo modulius. Įėjimai sudaromi per sistemos jutiklius, išėjimai – per vykdiklius. Intelektualioji sistema yra pranašesnė nei tipinė valdymo sistema. Il. 3, bibl. 8 (anglų kalba; santraukos lietuvių, anglų ir rusų k.).

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Intelligent agents continuously perform following functions: perception of dynamic conditions in the environment; action to affect conditions in the environment; and interpreting perceptions, solve problems. The architecture of intelligent control system, general components of intelligent system and interconnections between them is introduced in this article. Any intelligent control system consist of two parts: internal (computational) and external – interface between the real world and application. The internal part can be decomposed into four modules: sensory processing, world modeling, behaviour generation and value judgement. Input to internal part of intelligent system are realized by sensors, and output – by actuators. Intelligent systems represent increment in behavioral requirements compared to typical control systems. Ill. 3, bibl. 8 (in English; summaries in Lithuanian, English and Russian).

В.ココ Тересюс. Основы архитектуры интеллектуальной системы // Электроника и электротехника. – Каунас: Технология, 2005. – № 7(63). – С. 53-56.

Интеллектуальные агенты непрерывно выполняют следующие функции: восприятия динамических условий в среде; влияния на среду и интерпретации восприятий, решения задач. Исследуется архитектура интеллектуальной системы управления, главные части этой системы и связей между ними. Интеллектуальную систему можно разделить на две части: внутреннюю и внешнюю, связь между реальном миром и программой. Внутреннюю часть можно разделить на четыре модуля: обрабатывания сенсоров, моделирования мира, генерирования поведения и величин. Вход во внутреннюю часть системы реализуется через сенсоры, а выход – через актуаторы. Интеллектуальная система имеет больше преимуществ в требованиях поведения системы по сравнению с типичной системой управления. Ил. 3, библ. 8 (на английском языке; рефераты на литовском, английском и русском яз.)