APPLYING PSYCHOANALYTIC AND NEURO-SCIENTIFIC MODELS TO AUTOMATION

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ABSTRACT

Project ARS (artificial recognition system) researches the future possibilities for building automation using bionic approaches. It focuses on the combination of bottom-up data processing systems with decision making inspired by modern psychoanalysis. We define a model based on a symbol processing unit and a decision unit implementing Sigmund Freud’s Ego-Superego-Id personality model, emotions and drives. This paper describes the basic principles of decision making and the complete connection down to sensors level, it shows some of the challenges in the process and first steps of implementing a prototype system.

INTRODUCTION

The long-term development of building automation as we see it today goes towards building intelligent autonomous systems, which are capable of dealing with a huge number of inputs, recognizing scenarios and reacting in an appropriate and flexible manner Pratl and Palensky (1).

In near future the cost for sensors used in building automation system will drop, causing an increased amount of available sensor data that needs to be processed. Even today, the use of visual and aural equipment allows processing of large data streams containing a lot of relevant information. The question that needs to be solved in near future is how to process the increasing amount of data in order to extract relevant information and discard unimportant information. The task of future automation systems is thus to perceive more and more complex scenarios in a human environment like office buildings or private homes. The classic approach of control engineering will not be able to adapt to this complexity.

As suggested in Pratl et al (2), we approach the problem from two sides:

- *Bottom Up*: PC (Perceptive Consciousness) reduces the sensor data in three steps by using symbolic information processing: micro symbols, snapshot symbols and representation symbols are used to condense sensory information up to a level, where a representation of the environment is available. At its highest level, PC aims at perceiving scenarios, e.g. a person walks from the refrigerator to the coffee machine.
- *Top Down*: PA (PsychoAnalysis) is a bionic approach to decision making. Sigmund Freuds Ego-Superego-Id personality model and its input on memory and consciousness is condensed to a technically applicable system. Emotions as described by the psychoanalytic theories help to classify the information perceived. Furthermore, emotions and their impact on perception and memory help to recognize critical scenarios.

The combination of these two partly complementary approaches results in a model for a system able to perceive real-world sensory information and evaluate this data–augmented by a priori knowledge about the world. Evaluations and decision making is taken from the domain of psychoanalysis, while perception and world modeling is based on symbolic processing adapted from the current knowledge about human perception.

BACKGROUND

The demands to building automation systems are increasing with the availability of sensors. Today simple monitoring of the environment (e.g. temperature) and adjusting it to predefined value ranges targeting comfort and energy preservation is the main purpose of such a system. This will shift in the future towards applications like safety and self-learning environment-control. An example for safety is nursing of children–detection of possible dangerous scenarios in rooms where unsupervised children are.

The new demands that arise from these new applications are:

- Reduction of information
- Filtering of information (focus of attention)
- Condensation of information (explicit vs. implicit knowledge)
- Scalability for the decision making processes (from simple well known tasks up to complex and/or new scenarios)
- Native safety awareness
- Native social competences

Our approach to fulfill these demands is to combine a bottom-up model PC (reduction of sensor data to symbols and creation of a world representation) and a top-down model PA (applying psychoanalytical models to decision making). The first three demands are covered by PC, whereas the last three are part of PA While the concepts of reduction, filtering, condensation and scalability are also part of other approaches towards building automation, the concepts of native safety awareness and native social competences are new.

Emotions are not new to robotic and can be transferred towards building automation. In Arbib and Fellous (3) different approaches to emotional robot-architectures are discussed and the neurobiological roots of emotions are explained. This explanation is sufficient for the basic body focused emotions, but social emotions can not be sufficiently explained by neurology alone. Theories from psychology and psychoanalysis have to be consulted to understand their functionality. Solms and Turnbull (4) focuses in this direction–the connection between neurology and psychoanalysis.
Applying Sigmund Freuds psychoanalytical “holistic” model we have three components to satisfy our demands: 1. basic and complex emotions, 2. unconsciousness, preconsciousness and consciousness, and 3. id, ego, superego. Basic emotions in combination with id and superego are liable for native safety awareness which belongs to the instincts of self-preservation. Complex emotions, superego and ego are responsible for native social competences. The three grades of consciousness are defining if the ego as the highest reasoning unit can reflect on why a certain emotional state has been reached, what are the current goals etc. All three components together are helping to build a scalable system where routine tasks are fulfilled in an early stage of processing. And–as an outlook into the future–it is more likely that an emotionalized system can recognize and interpret the mood/emotional state of its users (e.g. in a nursing home).

The ego is the interface between inner and outer world and represents the perception of both. It is also the executive “organ” which controls motor function. Demands by the outside world and demands of superego and demands of emotional and drive origins are integrated. Memory systems therefore belong to the perception of the inner world, part of them conscious, preconscious, or unconscious.

The early stages of learning and childhood imprinting are skipped in our model. Information that would naturally be retrieved in those years is implemented as implicit rules and a-priori knowledge.

NEUROSCIENTIFIC FOUNDATION

An important task to push development in building automation is to create a link between sensor level data and symbolic processing methods. Current systems operate on information that originates from a limited amount of sensors. While this frees the system designer from dealing with redundant and maybe contradictory information, the view of the environment, which is

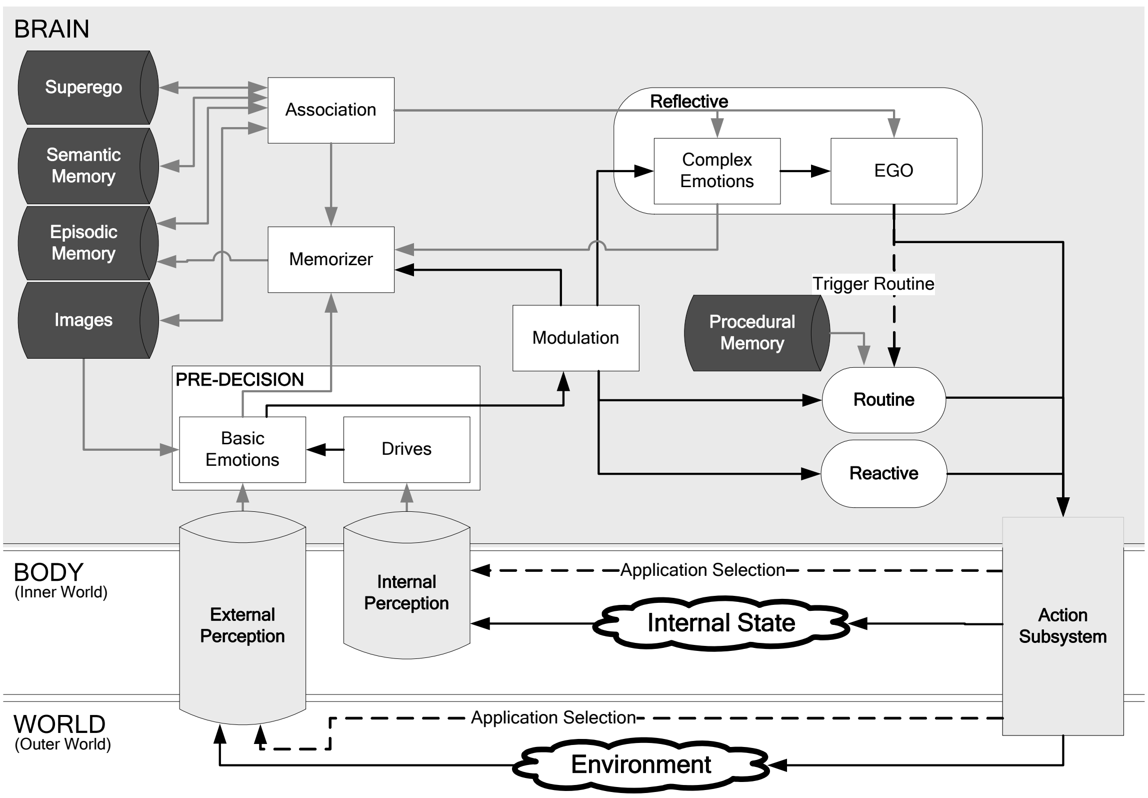

Figure 1: System Model

available to the system, is limited. A room temperature control application, for example, could operate a lot more precise, if it would know about the presence of persons. The system described in this paper applies models that are taken from neurosciences to process sensory information. While the human brain operates with neurons as the key element for data processing, a technical system has to be based on a set of algorithms, which have similar abilities, but can be implemented in hard- or software, thus substituting the biological base by a technological one. Edge detection algorithms substitute the ability of hypercomplex cells in the optical cortex Goldstein (5); the detection of movement as it is found, for example, in pigeons for approaching objects Wang and Frost (6), is implemented as motion detection algorithms.

Data processing takes the step from sensory information to symbolic representation of data. While symbolic artificial intelligence (AI) has different means to process symbolic information, it lacks an important property. As explained in the Chinese Room Experiment Searle (7), a system operating on symbols must not be mistaken with a human mind (who's mind can also be modeled as a mechanism operating on symbols), because the person who operates on symbols is able to "understand" the symbols. Just because a symbol is called "dog" by a human programmer does not imply that the system understands the concept of a dog (although it may know about the relation between "dog" and "bark"–another meaningless name). This symbol grounding problem, which has–amongst others–been addressed by Fodor (8), is considered here in the following way: while the symbols in the system cannot be assigned a "parasitic" meaning (i.e. calling a symbol "door" does not explain the concept of doors), the system has "grounded" information about the real world it is embedded in. Using its sensors, it has an interface to retrieve information about the environment. This sensory data, which has no semantic meaning, is linked to a primitive layer of symbols (called *microsymbols*). Thus, the system has a connection that allows it to operate on grounded symbols.

By employing assumptions about the information perceived by the sensors, the system is able to create a world representation. For example, tactile floor sensors, which are triggered by weight, can be used to deduce the existence of persons or objects. Under the assumptions that only persons (and not objects) are able to move autonomously, the system can assume a person being present. This knowledge is available as semantic memory (see next section).

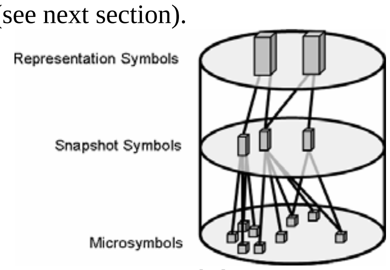

Figure 2: Symbol generation

Perception

One can only perceive what one has learned[1] to perceive Singer (9). Similarly, the system is able to perceive facts and events that it knows. An additional area of research is how to let the system learn new facts in order to improve its understanding. This is however not in the scope of this paper. Perception aims as condensing incoming sensory information into symbolic information. Symbolic information consists of three levels of symbols (see Figure 2: Symbol generation): sensor data is condensed to microsymbols, which are comparable to pieces of information in the human brain, which are the result of the first level of neural processing (e.g. visual clues like edges or motion in the optical cortex). Using microsymbols, the next layer of symbolization is created: *snapshot symbols*. A snapshot symbol contains the representation of the world at a certain instance (or in a short time period). Such symbols exist only in this instant and are destroyed afterwards. Snapshot symbols are used to create the representation level. At this level of symbolic processing the system has a consistent view of the world. As opposed to snapshot symbols, the representation symbols are existing for a long time (e.g. as long as a person is visible for the system, the according symbol is updated, but never destroyed). On representation level, the system is able to access both the present state of the environment and the history of what has happened. Thus, it can search for *scenarios*, temporal sequences of events. Once a scenario is recognized, an according scenario symbol is created and becomes part of the representation.

Inner World vs. Outer World

Aside of the representation of the environment, which is observed by the system (referred to as the "outer world"), the system also has a second world representation: all components that are part of the system are also represented symbolically and are collected in the representation of the inner world. This representation (also called internal state) describes the conditions of the system e.g. the power level, which sensors are connected and their states, available memory storage–hence all internal information about the system. The environment is the “real world”. An action can affect either the inner world (e.g. suspending unneeded parts of the system) or the outer world (e.g. turning on the heating). Mostly both types of actions are executed parallel and depend on each other.

The two perception modules (*internal perception, external perception*) are responsible for extracting relevant information from sensory data and create the world representation for inner and outer world.

[1] Learning in this context includes evolutionary adaption of the species and individual learning.

PSYCHOANALYTIC MODEL

The system model shown in Figure 1 describes the functional blocks of the system. The inner and the outer world are perceived and condensed to representation symbols. These symbols alter the emotions and drive levels using the condensed information of the world in form of abstract images. The resulting emotions and drives are combined with the symbols to *scenarios* and are stored in the episodic memory. The three different decision units–reactive, routine, and reflective–are testing if and how they should react to the newly perceived scenarios. The action subsystem solves interfering action commands and finally executes them. The system aims primarily at observing its environment, hence these actions will usually be interactions with users.

In the *pre-decision* the resulting internal state is processed by the *drives* unit and the external state is handled by the *basic emotions* unit. The drives are working as thresholds. As soon as a certain level has been reached, the system tries to bring the drive back into its normal state (homeostasis). This means, that if the drive "hunger" is too high the systems will put the focus of its activities on reducing it (e.g. fleeing, fighting, hiding). By comparison of the external state with the images the basic emotions anger/fear are altered. Now the possibilities to lower the level of the drives are reduced. E.g. if the emotion fear is high, the option fighting may not be applicable.

Concepts like hunger, fear, fleeing, fighting are alien to the field of building automation systems. To be applicable they have to be translated. The drive “hunger” may be interpreted as ratio between consumed and available energy. A high “hunger” level would result in a reduction of currently non important services like heating in not occupied rooms.

Now the emotionally rated representation symbols are processed to their final state–the scenario–in the *modulation* unit. These newly generated symbols are distributed to the decision units and the *memorizer* unit. The memorizer collects the emotion (basic and complex) levels, the external and the internal state and the scenarios and stores them into the episodic memory.

The simplest decision unit is the *reactive* unit. A search for “if/then” rules fitting the current scenarios is executed. The resulting set of action commands is delegated to the action subsystem.

We distinguish between two types of routines to be processed by the *routine* unit: 1. instinctive routines and 2. intentional routines. The instinctive routines can be started autonomously–similar to the reactive rules–by a comparison between the current scenario and conditions for execution. The intentional routines have to be triggered explicitly by the reflective unit/ego. Each routine also defines, under which external conditions it will be able to run.

A routine is a set of action commands, which are executed until

- the external state does not fit the conditions any more, or
- the instruction set reached the end (routines may run in a loop)
- they are terminated by the reflective layer
- or they are overruled by a new routine (each routine has defined by which other routines it will be stopped)

The most time-consuming decision level is the *reflective unit*. It is split into two parts: the complex emotions and the ego. *Complex emotions* work similar to the basic emotions. While basic emotions are always predefined, complex emotions can be learned (comparable to raising children by teaching them rules for social interaction). Another difference is that complex emotions compare the perceived scenarios additionally with the episodic memory (basic emotions are only compared with the images). As a second type of input, the superego is used to bring in rules concerning social behavior.

The ego creates long-term plans to set the drives and emotions (basic and complex) back into homeostasis. These plans have to be evaluated regarding feasibility and reasonability. To fulfill this it has access to all memories utilizing the association module. As an outcome, the ego can trigger either an action or an intentional routine. If a sequence of actions appears regularly, it will be combined to a new intentional routine.

The association among the entries in the world knowledge (superego, semantic memory, episodic memory and images) is done in the *association* unit. This supports the ego unit in planning and evaluation. Also the condensation of entries in the episodic memory to new images is done here. Through this condensation explicit singular knowledge is transferred into implicit regular knowledge. This has to be done regularly to reduce the size of the episodic memory and the time needed for lookups. Furthermore, only implicit knowledge as represented by the abstract images is used in the basic emotions unit.

Finally, the action subsystem is triggered to execute the action commands. The action subsystem operates on symbolic information; it uses two types of symbols: action series symbols and action symbols. The top-level action series symbol contains a sequence of action symbols (i.e. temporal consecutive actions that need to be taken). The created symbols become part of the symbolic representation of the world; thus it is possible to reconstruct the actions of the system by looking at the history of the representation.

A special command of the action subsystem is the selection of a perception application. This means, that a different set of rules is used in the perception system to condensate sensor data to representation symbols. Applying this scheme the *focus of attention* is introduced. Thus the perception is adjusted to concentrate on a specific object or adapt to a specific kind of scenario. E.g. in normal operation mode the calculation of the number of people in a room is parameterized to minimize false positives and false negatives. In case of fire and smoke it may be better to accept more false positives to direct the relief units to possible injured than to risk that people die because the system decided that their level of recognition was to low.

Memories

Five types of memories are used: *Images*, *Episodic Memory*, *Procedural Memory*, *Semantic Memory*, *Superego*. Images is the most basic one. Each image is an abstract description of perceivable objects/scenarios. The other four memories are built upon associated scenarios represented by images. Episodic memory stores the events that were perceived in the past and provides historical data about previously made observations; semantic memory contains information about the possible interactions between images. Necessary information for routine execution is stored in procedural memory.

According to psychoanalysis the superego is not only storage of rules but also the place where these rules are applied to the scenarios. In this model the execution of the rules is located in the complex emotions unit. The superego stores rules about social norms. Similar to emotions and drives the concept of social norms has to be adapted for building automation systems. Thus information about permissible operation ranges for devices and norms about e.g. how many persons are allowed on the balcony is the content of the superego.

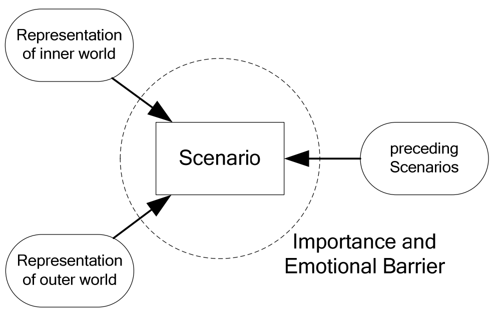

Figure 3: Components of a scenario

SCENARIO RECOGNITION AND DECISION MAKING

As explained in section Perception, every perceivable scenario has to fit into a template of a predefined generic scenario (in future we plan to generate generic scenarios automatically whenever reasonable). A generic scenario consists of a set of preceding scenarios, internal and external world representation (see Figure 3: Components of a scenario). We define an importance weight for each component and set a flag if it is mandatory. The sum of the ratings for the components classifies how well the observed situation fits into a given generic scenario.

The representations of inner and outer world are created by using scenario symbols. The rating and creation of these symbols is dependent on sensor data (followed by the multi-layered processing mentioned earlier) and the current emotional state. By linking together multiple scenarios it is possible to model more complex episodes.

The importance and emotional barrier works as a filter in two dimensions. First, all components of a scenario are amplified by the current emotional level. Second, states or situations which are after this amplification rated below a threshold are discarded.

Once a scenario has been rated, it is stored in episodic memory. Next it is compared to similar scenarios that have been experienced earlier. The emotion levels are altered in correlation to the found scenarios. This results in a cyclic dependency, in which first the perception of scenarios is influenced by emotions and afterwards these perceived scenarios influence the emotions. The emotions and drives reduce the set of possible actions to be chosen from by the decision units (this concept can be seen as the id in Freud's model).

The flow of processing now splits into two parts: 1. reactive and routine decision units and 2. reflective decision unit. No further processing of the scenarios is done for reactive and routine. The corresponding actions are selected regarding not only the perceived data but–equally important–also the current drives and emotional states. The resulting decisions represent past and present, the past as displayed by the emotions/drives. The advantage is, for example, that a threatening situation–which is for a short time not within the sensor ranges–is still implicitly known. Thus the selected actions are still handling this situation without the need to lookup the past.

For the reflective decision unit the scenarios have to pass one more stage–the complex emotions. This includes a second lookup in episodic memory and more emotions attached to the scenario. Then an action plan is calculated utilizing semantic and episodic memory. The superego provides information about what is allowed and possible in the current situation. The ego integrates the demands of superego, id and outer reality trying to lessen conflict and contradiction. This results in the selection of actions that should be executed which may overrule superego and id.

The action subsystem is responsible for execution of the actions selected by the three decision units. It is important that actions from a higher unit (e.g. reflective) are not overruled by a lower unit (e.g. reactive).

Consciousness

We define three levels of consciousness: 1. unconsciousness, 2. preconsciousness, and 3. consciousness. Unconscious information can never be reflected on; the system merely reacts according to it. Most of the model–especially the rules for rating scenarios according to the basic emotions–counts towards unconsciousness.
Only the ego can distinguish between unconscious and preconscious information. Thus outside of the ego preconscious information is treated as unconscious information. The ego can convert the preconscious information into conscious information if necessary. Converting is defined as the provision of the rules and conditions which led to e.g. a certain complex emotion. The ego can now adapt its plans to change this emotional level more precisely. Consciousness information can only appear inside the ego. Unlike the routine and the reactive units, the ego has knowledge about the goals to be reached. Additionally the plans can be tested inside a virtual environment.

In a small system the intermediate level precon-sciousness may be unnecessary and exchanged only by conscious information. In a large system the complexity is reduced by only converting preconscious information whenever the goals can not be reached satisfactorily without it.

PROTOTYPE IMPLEMENTATIONS

Two existing reference projects are available as basic development platforms, where the above-mentioned psychoanalytic and neuroscientific model is currently in implementation progress. The projects will embed this model into real world conditions and shall be briefly described here. They belong to different application areas and differ in their specific requirements, but are both autonomously acting systems.
Both applications consist of various sensors and actors to interact with the surrounding environment, a basic requirement for intelligent actions. In addition, both applications are performing their tasks in gathering information from their environment, analyzing the situation, estimating possible consequences based on previous learned situations and interact with the outer world.

Real and Virtual Autonomous Systems

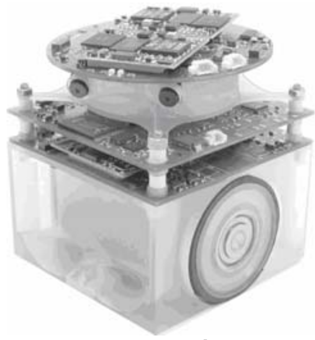

Figure 4 Tinyphoon

The first project is the two-wheeled robot Tinyphoon (Figure 4), a typical example for a miniaturized autonomous system with real-time behavior, described in Novak and Mahlknecht (10), including the aspect of embodied cognitive science. Combining various demands of automotive techniques e.g. objects recognition, path planning and traction control, Tinyphoon was especially designed and therefore field-tested in MiroSOT FIRA (11). A reasoning unit receives a significantly reduced amount of data in form of symbols. Due to these symbols a corresponding decision can be made. This decision-making unit was first based on preset state-machines combined with fuzzy logic algorithms to determine the best action out of a given set of actions, Egly et al (12).

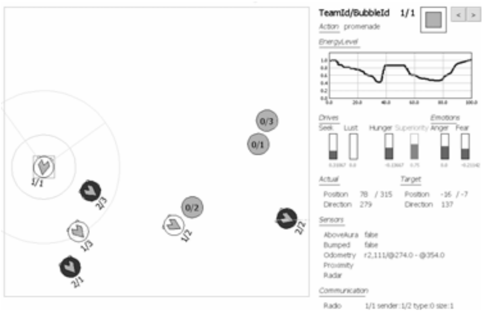

Figure 5 Visualization of bubbles

To validate the effort of implemented psychoanalytic models in the decision-making unit of a robot, a simulation environment (Figure 5) has been built. In doing so, the model of the soccer robot has been abstracted to virtual autonomous agents that we call - in analogy to their shape - bubbles. These agents can navigate through a two dimensional world by acceleration and rotation. Deduced from the soccer-robot, they are equipped with several sensors, such as an odometry sensor to measure relative positions, a bump sensor to detect collisions against other objects and radar sensors to detect and recognize other bubbles, obstacles and in this special scenario energy sources. The current goal of the agents is to survive in the environment by finding energy sources and filling up their energy level. In a first step, two drives were implemented into the robot. One drive was hunger that represents an energy level lower than a defined threshold. And the second one was an initially, given drive to seek for new information within the environment. Even though this first implemented behavior is based on that two, simple kind of drives and basic emotions, four of six agents survived over a complete simulation cycle. Further improvements of the behavior, such as the fear of opposite team bubbles or high occurrence of bubbles within a region showed a continuing increase of the bubbles time to live. The decision making unit should be supplemented with all relevant, missing parts of our psychoanalytic model described in section *PSYCHOANALYTIC MODEL* to validate the results in the simulation. When finished, the extended and developed decision unit will be applied to the Tinyphoon to get further expertise of advantages in a real world scenario.

Project Smart Kitchen

The second project is called *Smart Kitchen.* It is a room that is equipped with a high amount of diverse, widely used sensors and actuators that are used as an interface to the environment. The project aims to increase the level of comfort, security and quality of life for a person, using the kitchen. To do so, the Perceptive Consciousness Model was implemented in the system as mentioned above. Therefore it is able to extract data like the position of a person in the room out of divers sensory input or–more complex–recognize scenarios, e.g. based on a sequence of situations or symbols.

The tasks of a home environment application can be divided into the four functional groups: personal safety, system safety (including the house and the installation itself), comfort and energy management. To prove the system design we have selected the following situation: A pot of boiling water standing on a stove, steaming steadily into the air. First the system detects that the heater plate is turned on by the operator. Then the system perceives that the person is leaving the room although the heater is turned on. Next, humidity sensors are detecting a high ratio of humidity concluding that water is boiling in an open pot. Finally, humidity ratio is getting lower although nobody entered the room shutting down the heater plate. What the system should percept is that an empty pot is standing on the hot oven. Based on these sensor data, corresponding situation awareness and an episodic memory module, the system informs the human operator and takes further action.

On the left side of Figure 6 the technical realization of one specific type of sensor - the Smart Kitchen’s floor - is shown. The floor is equipped with an array of tactile sensors to be able to detect the coordinates where a person is located. This data is used to create microsymbols, which again cause creation or updates of more complex symbols (snapshot symbols and representation symbols). On the highest symbolic level (representation symbol), the system knows where a person is located in the kitchen and what path the person took. Based on the information on representation level, the system looks for scenarios and, in case a scenario (see Figure 3) is recognized, triggers an action.

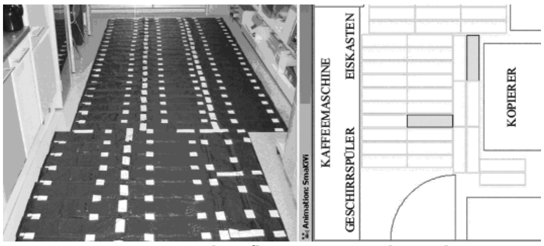

Figure 6: Smart Kitchen floor sensors and visualization

Furthermore the system predicts probable future actions of the person, such as the predictions of future locations of the person.

The right side of Figure 6 shows the graphical visualization of the floor sensors with highlighted squares indicating the location of a person.

CONCLUSION

We have presented a system model that combines the bottom-up approach of creating symbols out of sensor data and the top-down approach of applying modern psychoanalysis to decision making. As a result we gain four powerful mechanisms: 1. the condensation of symbols, 2. pre-evaluation of the scenarios using emotions, 3. separation of decision making in reactive, routine and reflective, and 4. the three levels of consciousness.

Two different kinds of applications are targeted as platforms for our model. Smart Kitchen is an area providing different kinds of scenarios that can be recognized, making it a perfect environment for a building automation system. While the kitchen interacts only with humans, our autonomous agents (soccer robots and bubbles) are interacting only amongst themselves. The resulting “social environment” allows us to implement complex emotions to human complex emotions.

Although there are still open research fields represented by the reflective unit, the memory units and by the study of cooperative behavior, we are encouraged by the good results of the first simulations of our model based upon basic emotions for evaluation of situations and possible actions. These intermediate results show clearly that using emotional pre-evaluated situations the pool of possible actions is reduced by one third and thereafter accelerates decision making.

REFERENCES

1. Pratl, G. and Palensky, P., 2005a, Proceedings of the IEE International Workshop on Intelligent Environments, 2005, p. 55.-62., “Project ARS - The next step towards an intelligent environment”
2. Pratl, G. and Penzhorn, W.T. and Dietrich, D. and Burgstaller, W., 2005b, IEEE 3rd International Conference on Computational Cybernetics Proceedings, Mauritius 2005, “Perceptive Awareness in Building Automation”
3. Arbib, M.A. and Fellous, J.-M., 2004, TRENDS in Cognitive Science, Vol.8 No.12, “Emotions: from brain to robot”
4. Solms, M. and Turnbull, O., 2002, “The Brain and the Inner World”. Karnac/Other Press, Cathy Miller Foreign Rights Agency, London, England 2002
5. Goldstein, E., 2002, “Wahrnehmungspsychologie - Eine Einführung”. 2. Auflage, Spektrum Akademischer Verlag, November 2002
6. Wang, Y. and Frost, B.J., 1992, Nature, 1992, 356(6366), p. 236-238,” Time to collision is signalled by neurons in the nucleus rotundus of pigeons.”
7. Searle, J., 1980, Behavioral and Brain Sciences 3, p. 417–424, 1980, “Minds, Brains, and Programs.“
8. Fodor, J., 1988, In: The robot's dilemma: the frame problem in artificial intelligence. 2. print, ed. by Z. Pylyshyn. Ablex Publ. Co., Norwood, NJ, 1988, “Modules, frames, fridgeons, sleeping dogs and the music of the spheres.“
9. Singer, W., 2000, “Wahrnehmen, Erinnern, Vergessen - Über Nutzen und Vorteil der Hirnforschung für die Geschichtswissenschaft: Eröffnungsvortrag des 43. Deutschen Historikertags am 26.09.2000 in Aachen“
10. Novak, G. and Mahlknecht, S., 2005, Proceedings of the IEEE International Symposium on Industrial Electronics 2005, 6
11. FIRA - Federation of International Robosoccer Association, 2006, [Online], available at: http://www.fira.net/soccer/mirosot/ overview.html [accessed on March, 21st 2006]
12. Egly, U. and Novak, G., Weber D., 2005, 1st CLAWAR/EURON Workshop on Robots in Entertainment, Leisure and Hobby Proceedings, 2004, p. 69-72, “Decision Making for Mirosot Soccer playing Robots”

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