Semantic Representation for Emotional-Behavioral Systems

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Abstract—The paradigm of intelligent space integrates the knowledge of several scientific fields. The intelligent space approach can be successfully applied for home care of handicapped and elderly people. The use of semantic information proved to be an efficient method for the knowledge integration of different domains. In this paper, a semantic intelligent space framework is presented which can handle the capabilities and needs of the single intelligent entities in order to realize cooperation for solving complex tasks. This semantic framework is extended with the representation of the further domain of emotional-behavioral systems. It is described, what kind of benefit can be realized based on the results of this domain, then the semantic representation of the domain is explained. It is described as well, how the original framework can be extended in order to cope with the representation.

Index Terms—Intelligent space, Emotional system, Behavioral system, Cognitive Info-Communications, Semantic information

I. INTRODUCTION

Intelligent space provides a communication framework for different kinds of intelligent devices to interact with human users and each other in order to perform complex tasks together. In this way, the framework integrates the knowledge of the single devices. The matching between the capabilities and the needs of the single devices is a rather big challenge. The semantic representation of the capabilities and the needs can improve the efficiency of this matching. The first general intelligent space framework which applied semantic information for this kind of knowledge integration was developed during the ASK-IT project [1]. The single application domains were represented in the form of ontologies, but the different semantic representations rose the problem of ontology matching. For the solution of this problem, an integration framework was developed during the OASIS project which intended to operate over a heterogenous set of different ontologies [2] [3] [4]. This kind of semantic integration was improved during the ACCESSIBLE and the AEGIS projects [5] [6] [7].

With the help of semantic information, the efficiency of matching between the capabilities and the needs of intelligent devices could be improved. To join this field of research, an intelligent space framework was developed at MTA SZTAKI as well [8]. The interaction between intelligent devices and human users is a hot topic of cognitive-infocommunications [9]. It seems to be a good attempt to model human users in the framework as well as emotional-behavioral systems to improve the efficiency of this interaction. During the research, human users and intelligent systems were both modeled as CogInfoCom systems with CogInfoCom engines. CogInfoCom engines can model human users as emotional-behavioral systems based on different approaches.

The results of cognitive info-communications were taken into account during the development of the intelligent space framework [10] [11] [12]. In the framework, the interaction between human users and intelligent devices is modeled according to the approach of CogInfoCom [13] [14]. The developed framework is unique in the sense that a semantic representation of emotional-behavioral systems is presented from the viewpoint of cognitive info-communications. Moreover, the semantic representation of the domain is added to an existing semantic intelligent space framework in order to improve its efficiency.

The effect of this extension were demonstrated on the semantic intelligent space framework. This framework is based on the VirCA system, so it has the VirCA core component on the one hand, and different cyber devices on the other hand, cyber devices for the single intelligent devices. The semantic manager of the framework is a cyber devices as well. The ontology manager of the framework handles the ontologies of different domains [Fig.1].

There are two ontologies in the current configuration of the framework. The general intelligent space ontology is responsible for the representation of the capabilities and the needs of human users and intelligent devices, and based on this, for the matching of the capabilities and the needs in order to realize cooperations. The human ontology is responsible for the representation of the emotional states and the internal and external behavioral factors of the user.

The build-up of the emotional-behavioral framework is presented together with the applied technologies in the first part of the paper. To support a better understanding of the
framework, several demonstration scenarios are presented in the second part of the paper before the final conclusion.

II. APPLIED TECHNOLOGIES

The VirCA system was chosen as an intelligent space platform for the representation of the physical room and for the management of physical and virtual objects [15]. The VirCA platform can be applied for distributed collaboration of different intelligent devices connected through the Internet [16].

Separate cyber devices were developed for each intelligent device of the framework. Cyber devices are connected on the one hand, to the VirCA core component, and on the other hand, to the controllers of the different devices. In this way, all the devices are connected over the VirCA platform. Through the communication space of the VirCA platform, cyber devices can interact with each other in order to realize some cooperation. The semantic manager component of the framework is a special cyber device which instructs the other devices. The semantic manager component is connected to the ontology manager component as well. [Fig.2]

The developed ontologies are represented in OWL-DL 1.0 at the moment, but in the future, it is planned to upgrade to OWL 2.0 because of its benefits. For the management of the ontologies, the editor and the libraries of the Protégé framework were used. The Jess rule engine was applied to realize machine inference based on the semantic information, because it has the appropriate interfaces for the Protégé framework.

In order to handle the inexact nature of semantic concepts, fuzzy facts can be applied in the ontologies, e.g. for the representation of the emotions of the user. In this case, inference rules are replaced with fuzzy inference rules which can handle cognitive biases as well [17] [18].

III. BUILD-UP OF THE SYSTEM

The emotional-behavioral system consists of several functional parts. Different components are responsible for the collection, for the representation and for the application of emotional-behavioral information about intelligent entities which are treated as CogInfoCom engines in the possible interaction processes.

The collection component is responsible for the input of emotional-behavioral information. This can happen through different kinds of triggering of the intelligent entity in question. The type of triggering corresponds to the nature of the entity and the aspect of interaction in which the entity takes part. One possible solution in case of a human user is the visual triggering of human facial expression and gesticulation. However the detection of the face and the processing of image information is an effortful challenge. One other solution in case of human user is the analysis of speech prosody information. There is a huge body of relevant research and there are ready-to-use solutions in the topic of prosody-based emotion detection. [19] The best solution is the simultaneous application of different methods, e.g. in the case of a human user, the concurrent application of visual- and vocal information-based emotion detection.

The representation component is responsible for the storage of emotional-behavioral information in such a form that it can easily be applied for further inference. Semantic information seems to be an appropriate form for this purpose. In order to represent emotional-behavioral information about the user, a special human ontology was developed during the research. Originally, the human ontology was developed to model the needs and capabilities of the human user [20] [21]. The field of capabilities covers the physical capabilities of the user as well, whether the user has different kinds of handicap. The instance of the old lady can have different instances of capabilities as properties such as the capability of walking short distances without a walking frame, the capability of walking long distances with a walking frame, etc. This ontology was extended in such way that on the one hand, it can cope with the different emotional states of the user and on the other hand, with the behaviour of the user which is determined - among...
others - by the customs of the user and external restrictions, e.g. instructions and prohibitions of other people. There can be a rule that if the user has a bad mood as property, the user does not have the affinity for the action walking, but if the user has a good mood as property, the user has the affinity. It can be a restriction that an other person, e.g. the house doctor enables or disables the action walking for the old lady. The internal and external facts can be combined in the rules as well that e.g. if the old lady is in a good mood, she is ready to follow the instructions of the doctor, but if she is in a bad mood, she does not pay respect to them at all.

The application component is responsible for the use of emotional-behavioral information. This can happen normally through machine inference based on a set of explicit facts and rules, allowing implicit facts to be inferred and added as explicit facts to the representation. This component usually incorporates a connection to the former parts of the system, as emotional-behavioral information does not stand in itself, but in relation with other, formerly represented kinds of information. According to this, the existing inference rules are usually extended with facts of emotional-behavioral information. For example, an existing rule can be that if an old lady has the capability of walking with a walking frame, the walking frame needs to be where she is. This rule can be extended in the way that if the lady is in a good mood, she has the affinity of walking, but if she is in a bad mood, she does not have the affinity. The instructions of the house doctor, whether the old lady should walk or not, can be represented as well. This rule can be further extended so that if the old lady is in a good mood, she will follow the instructions of the doctor, i.e. walking if instructed, while if she is in a bad mood, she does not want to get out of her bed regardless of whether the doctor instructed her to walk or not.

In most cases, where there are more possible solutions, the emotional-behavioral extension makes the framework capable of selecting the solution which the user appreciates the most [22]. During communication with the user, there can be more communication patterns according to the emotional state or communication habit of the user. The framework can choose from these patterns based on the current emotional-behavioral information about the user. The pattern is substituted with the current data of the interaction.

IV. APPLICATION EXAMPLE

Several simple demo scenarios are implemented for the demonstration of the research results. On the one hand, the capabilities of the intelligent space ontology are demonstrated, and on the other hand, the capabilities of the special human ontology which represents the emotional-behavioral information about the user. [Fig.3]

The location of the demonstration is a house of an elderly woman who applies the intelligent space framework for home care. There are two floors in the house, the kitchen, the dining-room and the sitting-room are located on the first floor, while the bedroom and the bathroom are located on the second floor. There are two cases, where the elderly woman can be found, she is either sitting on a sofa in the sitting-room watching television, or she is having a bath in the bathroom. The visual information of the user is recorded by camcorders in the single rooms, while the vocal information is recorded by microphones. Emotional information about the elderly woman is gathered processing the visual and vocal information of her. The framework can be controlled through voice commands of the user.

The house is equipped with several intelligent devices. There are different mobile devices among them which can be applied for the transportation of objects. There are mobile robots as well which are able to manipulate objects, e.g. open the door of the fridge, of the microwave-oven, put objects into the fridge, into the microwave-oven, take out objects of the fridge, of the microwave-oven, put objects onto the table, put objects onto other mobile devices, etc. Some mobile devices can use the elevator as well which provides a transit between the two floors of the house.

In the first case, there is a phone call to the cellular phone of the elderly woman. This is a direct push trigger, because it is not the user who triggered the event, but an other person, who directly called the user. The cellular phone is situated on the desk in the bedroom. The elderly woman is either watching television in the sitting-room or having a bath in the bathroom. It is known that if the elderly woman is in a bad mood, she does not like to answer phone calls at all, but if she is in a good mood, she likes to. But if it is an important person who is calling, e.g. a close relative or friend of the elderly woman who probably takes care of her, she has to answer the phone after all. So if the phone rings, it is considered first whether the elderly woman is in a good or in a bad mood. If she is in a good mode, the phone is delivered to her. If she is in a bad mood, it is taken into account, who is calling her. If it is an important person, the phone is delivered to her. If not, it is not delivered. To deliver the phone from the bedroom to the bathroom only one mobile robot is needed. But to deliver it from the bedroom to the sitting-room, one mobile robot is not enough. The phone is delivered to the elevator by a mobile robot, then it is passed to a mobile device which fits into the elevator. The elevator is taken from the second floor to the
first floor, then an other mobile robot delivers the phone from the elevator to the sitting-room.

In the second case, the elderly woman wants to have some sweets. This is an indirect pull trigger, because it is the user who triggered the event, but the user does not explicitly know what kinds of sweets is at home, the framework decides. There are two kinds of sweets at home, one of them is dietetic, the other is not. The elderly woman prefers the non-dietetic sweets, but her dietitian can forbid her to eat them. It is known that if the elderly woman is in a good mood, she follows the directions of her dietitian, but if she is in a bad mood, she does not follow them. Both the dietetic and non-dietetic sweets are situated in the fridge in the kitchen. The elderly woman is either watching television in the sitting-room or having a bath in the bathroom. So if the elderly woman asks for sweets, it is considered first whether she is in a good or in a bad mood. If she is in a good mode, the directions of her dietitian are taken into account. If the elderly woman is allowed to eat non-dietetic sweets, they are delivered to her, but if she is not, dietetic sweets are delivered. If she is in a bad mood, dietetic sweets are delivered to her regardless of the directions of her dietitian. To deliver the sweets from the kitchen to the sitting-room only one mobile robot is needed. But to deliver them from the kitchen to the bathroom, one mobile robot is not enough. The sweets are delivered to the elevator by a mobile robot, then it is passed to a mobile device which fits into the elevator. The elevator is taken from the first floor to the second floor, then an other mobile robot delivers the sweets from the elevator to the bathroom.

V. CONCLUSION

It was demonstrated with the help of the developed proof-of-concept framework that the use of semantic information eases the improvement of knowledge-based systems. The semantic representation of the field of emotional-behavioral systems could be easily added to the existing semantic intelligent space framework. Based on the semantic representation of the domain knowledge, the framework could produce the expected operation. The knowledge of different domains can be utilized using the semantic representation. In the future, it is possible to integrate ontologies of further domains into the semantic framework.

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