Development of Human-Centered Social Robot with Embedded Personality for Elderly Care

Aleksandar Rodić, Milica Vujović, Ilija Stevanović and Miloš Jovanović

Abstract The paper regards to research and development of a human-centric, social, care-robot for elderly people and persons with reduced ability to improve quality of their life and to create conditions for more independent living at their homes. Paper presents new mechanical design of personal robot assistant operating in an informational structured environment arranged in the form of a smart house. The paper suggests mechanical structure of the robot that meets ergonomic standards adapted to the low mobile or immobile patients. Fine ergonomic characteristics of robot allow better support for low mobile patients while walking and relatively easy to use services offered by the robot such as: adding of items, medications, personal belongings, serving drinks and meals, connecting and use of the Internet or social networks, phone calls to family members or friends, use Skype services, etc. The robot has a built-in security features such as emergency for medical services, emergency call to family members, etc. Proposed care-robot includes artificial intelligence additionally enhanced by the emotional intelligence interface that enables better adaptability to different personality profiles. In the paper, the care-robot is put in the context of a cloud system that enables enhanced sensing, fast communication between agents as well as real-time decision making and operation. The way of personality embodiment with care-robot is described in

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the paper and the methodology proposed was explained by an example—the use case entitled “broken glass”. In the conclusion, main novelties and research objectives are stressed out as well as the future work is proposed.

Keywords Human-centric robots • Care-robots • Assistive-living technologies • Embedded personality

1 Introduction

Estimates from the United Nations suggest the population over 65 worldwide will increase 181 % between 2010 and 2050, compared to a 33 % increase in people aged 15–65. That shift will create a large incentive to automate at least some assistive work. Because over the next 20 years the ratio of people over the age of 65 to the number of people under 65 is going to change rather dramatically. As robots become safer, smarter, and more capable, robotics companies are eyeing elder care as a huge potential market. A rapidly expanding elderly population could also necessitate other new forms of home-assistance i.e. assistive-living technology.

Personal assisted, human-centered, care and social robots could play an important role with respect to the health and psychological well-being of the elderly. Objectives of assistive social robots are believed to be useful in eldercare for two reasons, a functional one and an affective one. Such robots are developed to function as an interface for the elderly with digital technology, and to help increase the quality of life of the elderly by providing companionship. The use of these mechatronic devices in particular is justified in the attendance of elderly and people with limited physical and mental abilities in order to support their more independent lifestyle, and a better and safer life in his home. The growing of elderly population enlarges need for larger number of caregivers, cost of medical and social care and life insurance. Also, some scientific research in America and Europe have shown that most of elderly people feel happier and more comfortable if they are attended in their own homes rather than in shelters or elderly dormitories for the care of the elderly. In that sense, the level of care, attention, mental communication, emotional contact with these persons is of special interest. Is it possible by robots, as advanced intelligent devices, to respond to those psycho-physical, socio-economic and cultural challenges, is the question laid in front of the experts from both the humanitarian and the technical and technological sciences. The fact is that the global IT industry follows the needs and requirements of modern mankind and tries to offer right solutions in this sense.

The paper is organized as follows. State-of-the-art in the field is given in Sect. 2. The overview of the prototype structure as a whole is given in the Sect. 3. Problem setting in the context of an ambient-assisted living is done in Sect. 4. Development of the cognitive features of the system is considered in Sect. 5 through building of the embedded personality. The closing section contains a conclusion and future research.

2 State-of-the-Art

Companies are developing elder care robots with the hope of making people more independent in their life. Researchers and robotics companies worldwide are designing prototypes to provide automated assistance to the elderly at home, targeting a market that promises to grow as people live longer. In the past ten years a lot has been done in developing the so-called personal robots for care of the elderly, children, the sick and the handicapped. There are plenty of attempts making such service robots that have been developed for laboratory research. Truly speaking, the examples which are in commercial use are rare because there are still significant technological constraints and lacking knowledge of how to transfer human emotional intelligence to the robots.

One of the most successful help and care robot assistants for household is *Care-O bot 4* designed at the IPA Fraunhofer [1], Fig. 1a. The fourth edition of the Care-O bot range of caring and socially interacting robots has a more adaptable personality than any of its predecessors from this family of robots. It has a visual display which can depict various atmospheres, and the entire model has a more caring and personal feel about it. The Care-O bot 4 is incredibly adaptable, and can be used in various scenarios, including as a drinks waiter and a mobile information point. One of the main positive features of Care-O bit 4 is the attempt to decrease construction costs.

The Robosoft care-robot called *Kompaï* [2] resembles a plastic kiosk on training wheels, Fig. 1b. This robot features a touch-screen display on an easel and a bowling ball–size white head with a "face". The vision for Kompaï is as follows: Family members would call the robot via Skype. The robot would then use ultrasonic sensors to detect the location of the person being called and navigate to that person, who answers the Skype videoconference call via Kompaï's multitouch tablet PC and Webcam. Kompaï could likewise be used as an interface to *Facebook*, *MySpace* or some other social network. Interactive speech recognition would be available to help elderly or otherwise dependent people access the Internet using a simple graphic and tactile interface. Kompaï could also store a person's daily schedule and shopping lists, and access online calendars or weather. Robosoft also was looking for partnership with companies that make wireless physiological sensors worn by a robot's user that could communicate blood pressure, pulse, body temperature and other data via Bluetooth to the robot, which would then relay that information to the personal doctor.

The Robosoft company also developed a prototype of the RobuWalker [3], a human-assisted robot to help humans walking. This robot is only available in its research version (Fig. 1c). The RobuWalker is automated version of the passive walker device.

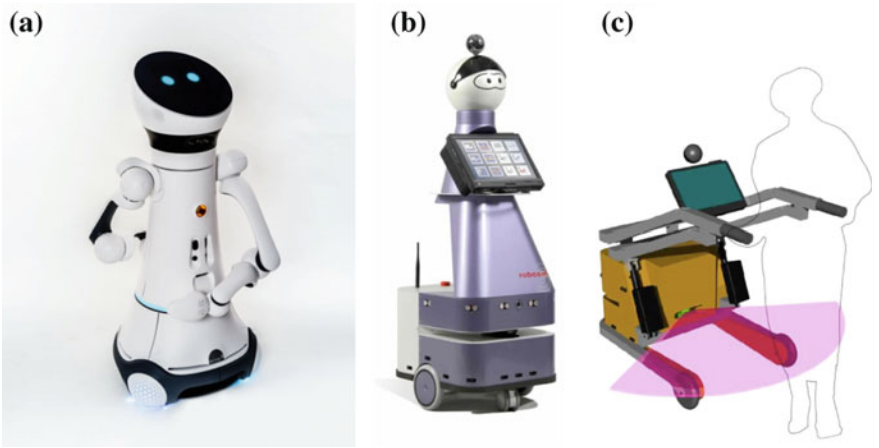

Fig. 1 **a** Care-O bot 4 human-assisted indoor robot, **b** The care-robot *Kompaï,* **c** The Robosoft RobuWalker

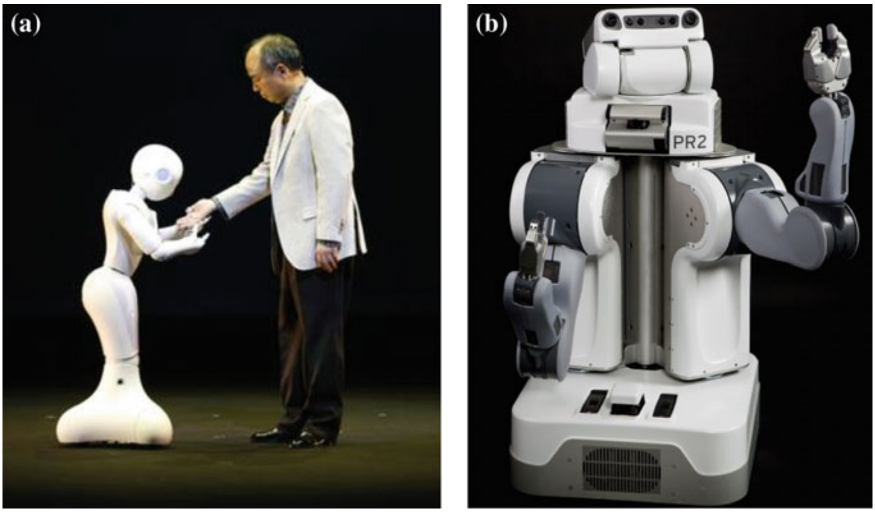

Fig. 2 **a** The SoftBank care-robot Pepper, **b** The Willow Garage personal robot PR-2

The Japanese *Pepper* robot (Fig. 2a) [4] uses a cloud-based AI system so that units learn from one another. Japanese technology giant SoftBank has unveiled a robot they claim is capable of understanding human emotions using an "emotional engine" and cloud-based AI. Standing roughly a meter tall with a tablet computer fixed to its chest, *Pepper* is expected to be used in a range of roles from caring from the elderly to baby-sitting. Pepper reportedly learns from human interactions, with each experience helping to teach a cloud-based AI shared by all units. It has fully articulated arms and hands but moves about on wheels hidden under a curved plastic skirt.

One of the most popular robots in the country is *Paro* [5], a furry, seal-like bot programmed to bond with its owners and show emotions such as happiness and surprise. Paro is an advanced interactive robot developed by AIST, a leading Japanese industrial automation pioneer. It allows the documented benefits of animal therapy to be administered to patients in environments such as hospitals and extended care facilities where live animals present treatment or logistical difficulties.

Willow Garage's first major robot is called *PR2* (Fig. 2b) [6]. It is of a size similar to a human. PR2 is designed as a common hardware and software platform for robot researchers. *PR2* is a robotics platform being developed at Stanford University. *PR* stands for "personal robot".

In parallel with development personal robots scientists focus their interest in developing robots with attributes of human personality to increase their cognitive capabilities. New generation of robots will not be a cold machine but ones that perceive emotion of others and are able to manage their own affective and social behavior. Recently Google has patented customizable robot personalities [7]. Newly-patented system would allow users to download the personality of one to a robot. Google has been granted a patent that would allow the company to develop downloadable personalities for robots drawn from the cloud. Robots that mimic humans are still very much in their infancy, and truthfully there's no telling where this technology can go—especially when backed by giants like Google. And while there's no guarantee that this patent will ever come to fruition, it may very well be the next step in making human-robot relationship a reality. This paper is contribution in that direction. The researches described in this paper refers to the progress in the following directions: (i) more attention was devoted to ergonomic design and better support for mobility of elderly, and (ii) better emotional and social adaptability of robot to the patients through embodiment of personality.

3 Mechanical Design

The body of the robot represents a monolithic entity with amorphous shape. Its form is intended to make the robot aesthetically attractive and ergonomic for humans (Fig. 3). Robot body carries the robot head placed on the collar (neck) that is basically continuation of the body and two 6 DOF robot arms with graspers.

Robot body doesn't have the ability to turn around its axis, but robot arms that have 6 DOF, collar and robot head that turns around vertical axis allow its mobility and operability in various positions. Robot body is equipped with ultrasonic sensors placed around lower part of the body, speaker and led light in the chest zone. Collar contains three cameras and it can rotate independently of the body and the head. Shape of the robot body is designed in a way that the lower part is wider and upper part is narrower so that the overall dimension would not exceed anthropometric

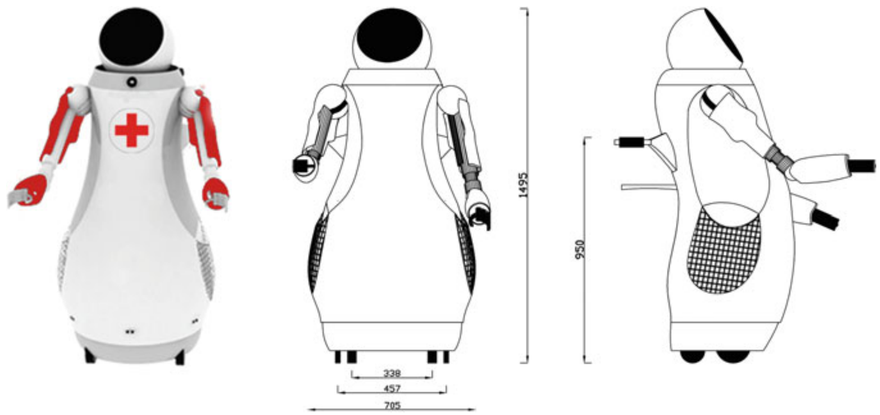

Fig. 3 CAD model of the human-centered care-robot of ergonomic characteristics

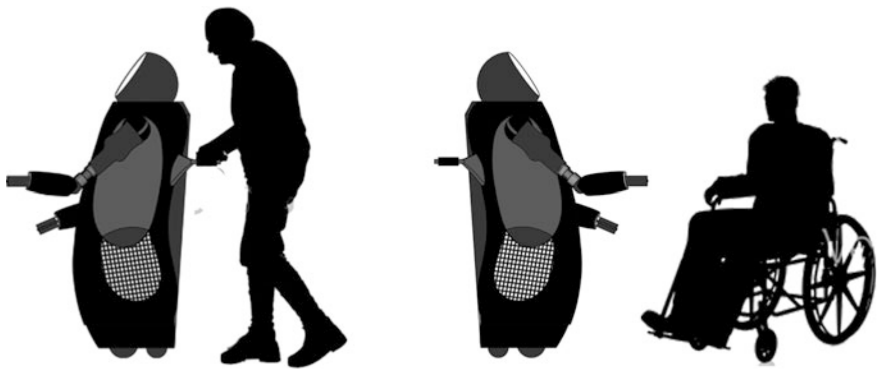

Fig. 4 Care-robot applications—supported mobility (*left*), human assistance (*right*)

limits when add robot arms. Following shape's design, two side pockets are added which serve as baskets for transporting lightweight objects or food. They are made of elastic net in order to provide ventilation for fresh fruit or vegetables that are carried in it. The bi-manual manipulation system consists of two lightweight robot arms of industrial quality. Arms are equipped with grippers. Two-arm manipulation system, combined with ability of turning head, provides good manipulation properties of the overall system and fine functionality (Fig. 4).

The robot head contains: (i) kinematic mechanism with 1 DOF, (ii) touch screen for command input and display information, (iii) three microphones with increased sensitivity, and (iv) optional visual depth sensor placed on the crown of the head. The head has good kinematic abilities of rotation around vertical axes. Based on fine visual and audio capabilities, the robot head can be rotated in direction of the source of the light and/or sound.

4 Ambient-Assisted Living

Advanced approach to support daily life activities of elderly people consists of creating a living environment supported by different technologies including wireless sensor networks and service robot(s). The elderly and people with disabilities tend to have difficulty in performing basic daily activities. Adjusting the physical environment (ambient) to make space more comfortable and ergonomic is not enough. It is necessary to set up an informational structured environment to enhance benefits of different technologies to be applied. Such systems represent adaptive systems, where the context is customizable, and adjustment is done by integrating circuitry in an intelligent system. In other words, living or working space for people turns into an intelligent environment—the smart house [8].

The robot is actually just part of the system (Fig. 5), which includes a kind of smart home aspect to it, with environmental sensors around the house feeding back information about the inhabitant's movements, movement objects, and physiological sensors to track their health. Motion sensors track if someone is in a certain room, while pressure sensors under beds and sofas can tell if someone is sitting down. There are also sensors that are activated when certain appliances are plugged in, and sensors that monitor when doors and windows are open or closed, temperature and humidity trackers, etc. Also, there are wearable body devices (Fig. 5) that measure

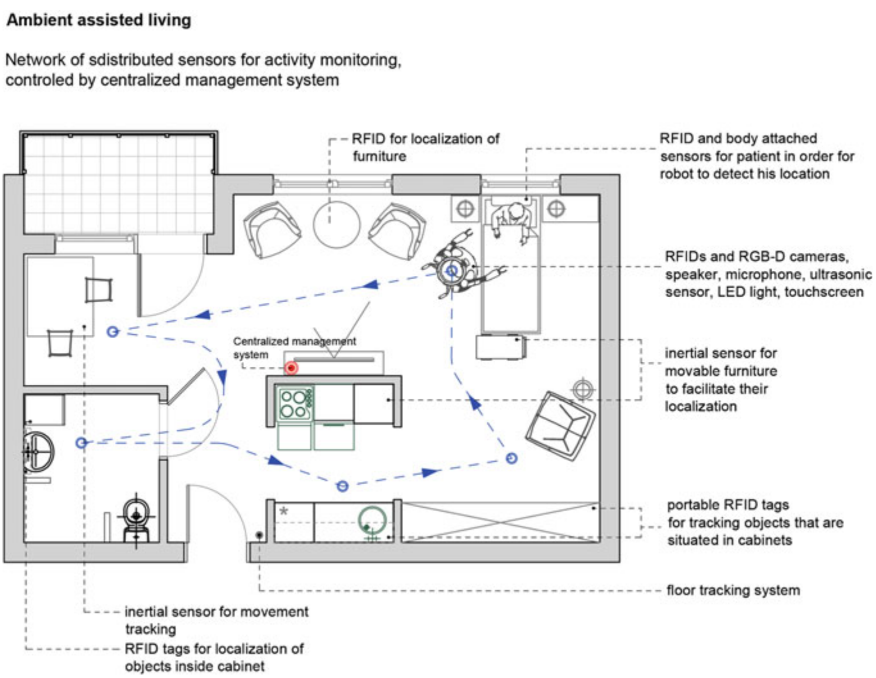

Fig. 5 The context of ambient-assisted living with care-robot of elderly

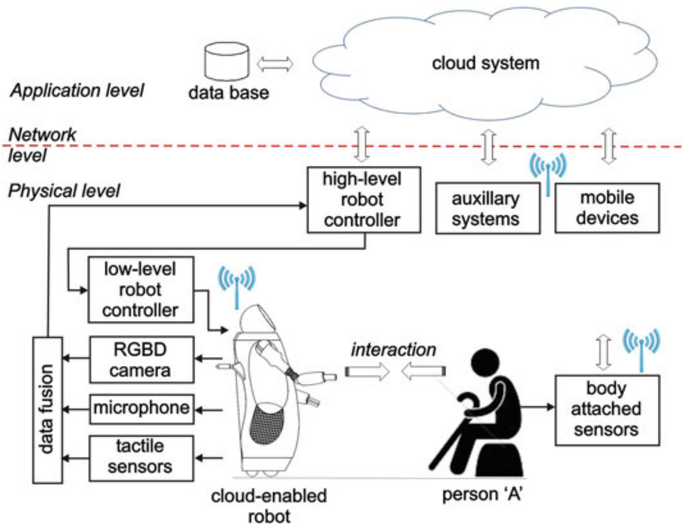

Fig. 6 High level system description—cloud-enabled care-robot operation

blood pressure, heart pulse, motion acceleration and so on. All of the data from the sensors is stored in the database. Based on this information we can extract some activities, like if the person is sleeping or the person got up during the night, the person is watching television or cooking, the person is anxious or calm, etc. The care robot, which is not autonomous, complements these tasks by allowing virtual visits from friends, family, and healthcare professionals. It's basically the equivalent of Skype on wheels. The user calls the robot and is able to direct it around the home to check in on the inhabitant. It's intended to make visits easier for those who aren't immediately at hand. Care robot on command is able to find and bring own objects required by patient(s), bring medicaments, meal or drinks. Based on RGB-D camera robot observes elderly gestures (body gestures as well face mime) and deliver information acquired to the cloud system [9, 10] (Fig. 6). The robot, devices and sensors put and used together create a 24 h monitoring system that demonstrates quite how machines can outperform us in roles that are traditionally considered inherently human, like looking after loved ones. Then there's the issue of collecting and fusion all that data into the cloud system developing a suitable interface for interpreting the constant stream of data over physical and social environment. By respecting privacy, only authorized persons (members of family or medical team) have access to the information, and they're able to see either a weekly or monthly report based on the data collected. The efficiency of the system depends on capacity of the cloud system (Fig. 6) that should enable fast and reliable communication amongst the system agents (robot(s), sensors, objects, human), processing and storing information. Overall system comprises three basic levels: (i) physical level that includes humans, robots, objects, sensors, etc., (ii) network level that enables reliable wireless communication between agents, and (iii) application level that collects, processes and store information about specific application including information about patient physical and psychological condition. The care-robot performs different caregiver service tasks such as assistance, nursing, monitoring, amusing, communicating and so on at the physical level but logistics for that (instructions how to do that, where, etc.) it receives from the application level.

Each activity of the robot requires certain activities of the environment. This activity of the environment is primarily there to help the robot and relieve him of additional sensors and complex algorithms.

5 Embedded Personality

Personality psychology is a branch of psychology that studies personality and its individual differences [11]. According to the theory, "personality" is a dynamic and organized set of characteristics possessed by a person that uniquely influences individual cognitions, emotions, motivations, and behaviors in various situations. Personality also refers to the pattern of thoughts, feelings, social adjustments, and behaviors consistently exhibited over time that strongly influences one's expectations, self-perceptions, values, and attitudes. It also predicts human reactions to other people, problems, and stress [12, 13]. This scientific discipline uses the Myers-Briggs Type Indicator (MBTI) assessment as a psychometric questionnaire designed to measure psychological preferences in how people perceive the world and make decisions [14]. The MBTI sorts psychological differences into four opposite pairs, i.e. dichotomies (*Extravert-Introvert*, *Sensing-intuitive*, *Feeling-Thinking* and *Perceiving-Judging*). That results in 16 possible psychological types. None of these types are better or worse. However, Briggs and Myers theorized that individuals naturally prefer one overall combination of type differences [15]. In the same way that writing with the left hand is hard work for a right-hander, so people tend to find using their opposite psychological preferences more difficult, even if they can become more proficient (and therefore behaviorally flexible) with practice and development. The 16 personality types are typically referred to by an abbreviation of four letters, e.g. ESTJ, INTJ, ISTP, etc. They can be acquired by filling out the on-line questionnaire available at [16]. The characteristics of all particular personality traits according to theory of Meyers and Briggs are presented in [15]. Here in Table 1 is listed only for the pair E-I with aim to explain the procedure of modeling human psychological behavior.

According to the Diagnostic and Statistical Manual of the American Psychiatric Association, personality traits are "enduring patterns of perceiving, relating to, and thinking about the environment and oneself that are exhibited in a wide range of social and personal contexts." Theorists generally assume that: (a) traits are relatively stable over time, (b) traits differ among individuals, and (c) traits influence behavior. They consistently are used in order to help define people as a whole. Traits are relatively constant; they do not usually change. Traits are also bipolar; they vary along a continuum between one extreme and the other (e.g. friendly vs. unfriendly).

Table 1 Personality traits of the dichotomy pair (E)-(I)

Extraverted versus Introverted (E)-(I)	
Talkative and sociable	Private
Expressive	Reserved
Would rather speak than listen	Would rather listen than speak
Comfortable around people	Tire quickly in social settings
Dislike being alone	Comfortable being alone
Get energized by communicating with other people	Get energized by being alone
Think while speaking	Think before speaking

Table 2 Overview of type temperaments and corresponding behavior attributes

Temperament	Behavior attributes
Sanguine (Sg)	Fast and short emotional reactions
	Variable mood
	Cheerful and optimistic person
Choleric (Ch)	Powerful emotions
	Impulsive and irascible person
	Affective
Phlegmatic (Ph)	Weal emotions and rare reactions
	Quite and poised
	Without abrupt change in emotional experience and reactions
Melancholic (Ml)	Rare but intensive and long-lasting reactions
	Long lasting mood under the influence of emotions
	Prone to the negative emotions, sadness and worry

Under the notion "temperament" it is assumed in psychology the individual kinds of the psyche traits that determine dynamics of human psychological activity [17]. The temperament traits are expressed in an even manner in any activity nevertheless to its' content, goals and motives, remaining invariant in the later years and which, in their interconnections, characterize the type of temperament. The temperaments are: *sanguine* (pleasure-seeking and sociable), *choleric* (ambitious and leader-like), *melancholic* (introverted and thoughtful), and *phlegmatic* (relaxed and quiet). The characteristics of different temperament types are summarized in Table 2 [17, 18]. A temperament type can be determined by filling corresponding questionnaires (tests) available at the Internet [19].

The embodiment of personality in robots can be achieved by implementing model of psychological behavior (i.e. the model of human affective and social behavior) with the attributes of personality and temperament [20, 21]. The model parameters are determined based on experience and experimental results obtained by processing of adequate filled out on-line questionnaire with human examinees (for detecting the type of personality [16], temperament [19] and the degree of affective reactions induced by particular excitation events). To do this, 237 patients of different gender and age have been treated. In determining the type of personality the Myers-Briggs type indicator was used which is based on the theory known in personality psychology [11, 14]. The mentioned theory emerged as the elaboration of Jung's (Carl Gustav Jung) theory of personality types [22]. When developing psychological (affective and social) personality model, research started from the original assumption that human behavior depends on several factors [18, 20] some of which are acquired by birth while others have evolved in the course of an individual's life as a result of the influence of physical and social environment on personality development.

According to this assumption, the factors that determine our behavior are: (i) the excitation event—called "trigger", (ii) type of personality, (iii) temperament, (iv) interior stimuli, and (v) external factors. The above listed factors cause changes in the emotional state of human, resulting in appropriate social-affective reactions (gestures, verbal, and/or physiological reactions). Excitation event or excitation case (trigger) is an event or circumstance in the environment that cause changes of human's emotional state and cause an appropriate response to developments in the surroundings. The interior stimuli are related to the physical and mental state of a person such as for example: fatigue, depression, illness, excitement, love, etc. External factors that influence behavior in humans are largely sociological factors like for example family upbringing, education, wealth, society influence, belonging to a community (religious and cultural), etc. It's difficult to say which of the above factors are more or less dominant upon behavior and there is no agreement among experts on this issue.

The dominance of the influence depends significantly on the tradition and culture of the nation to which an individual belongs. However, psychologists are of the opinion that the type of personality and temperament are dominant factors profiled by the man's emotional and social behavior. These factors are mainly acquired at birth, but in the course of life they somewhat vary depending on the living conditions and circumstances. Adopted psychological model of personality is presented on the block scheme in Fig. 7. The model was implemented as a three stage fuzzy

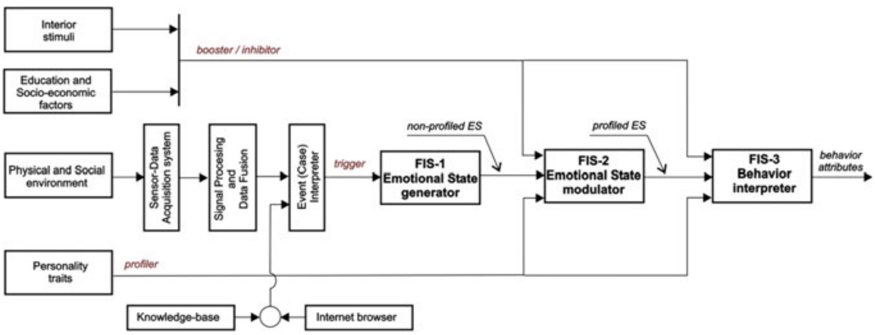

Fig. 7 Structure of the three-stage emotion-driven behavior model with the following fuzzy blocks: emotionally state generator, emotionally state modulator and behavior interpreter

logic, multi input—multi output (MIMO) system. Man as a biological being represents a multivariable dynamic MIMO system. The man behaves in a fuzzy way, often using incomplete or symbolic information. Input and output variables of behavior model are linguistic values as the example big-small, far-near, sad-happy, strong-moderate-low, etc. Fuzzy logic problem formulation allows it to translate the situation described by the symbolic or incomplete way into the determined numerical domain which can be implemented/processed in/by the microprocessor or in the robot controller [21].

The proposed model (affective machine or generator of affective behavior) has three stages of generating emotional state and behavior. At the output of the first stage (FIS-1 block) is obtained the so-called “non-profiled” emotional intermediary state (impersonal emotional state induced by trigger event), at the output of the second stage the profiled state is obtained (characteristic of a particular personality profile), and at the third output represents the emotion-driven behavior is obtained that characterizes the behavior of an exactly one person with corresponding type of personality and temperament. According to the model shown in Fig. 7 interior stimuli and external factors act as boosters or inhibitors of affective behavior. The model shown in Fig. 7 therefore represents a model of emotional intelligence and basis for building EI-controller [21].

Role of the robot EI-controller is to enable robot to acquire, to perceive (understand) and manage emotions (affects) of others and oneself. Having EI-controller robot achieves better social inclusion into the living environments and better adaptability to other persons. Core of the EI-controller represents a knowledge-based model presented in Fig. 7 [18]. The membership functions of the fuzzy blocks FIS-1 to FIS-3 are tuned based on experimental data obtained from the experiments with human examinees (using on-line questionnaires).

In the following paragraph we will describe how to implement the proposed model of psychological behavior in the robot controller. We discuss how to embody the personality traits within machines (robots). In order to achieve that, it is necessary to use appropriate sensorial system and communication equipment installed to the robot together with use advantages of cloud computing. Methodology will be explained by a simple example (use case) of a robot application. Let’s call this use-case “broken glass”.

Demo use case: Robot is required to bring a glass of water and medication to the patient. It is done in a way that the cloud forwards the information on a particular command to the system. Cloud takes the information about where the cup/glass is from the database, and where the water can be found. In the smart home, there are many sensors and many objects marked by the RFID markers. Also, the shelves are equipped with sensors that detect whether all the objects are in place or are relocated. This information is available for cloud system that sends the necessary information (notifies) to other agents in the room, according to their request for information. So, the robot moves to a location to take the cup, then to a place where it can fill up a glass of water. Path planning can also be dislocated outside of the robot controller on the cloud systems in order to relieve the robot controller of planning movement. It is done at the cloud application level (Fig. 6). Upon execution of this part of the task the robot is sent back to the user—patient. The robot approaches the patient and gives him voice information that it brings him water and medicine. Box with the medications robot carries in the side nets for disposal of objects (see Fig. 3). Robot lets know to the patient that the medication is in the side net and he/she can take it over if capable of doing manipulation. If not, the robot puts a glass of water and drug pill on a tray and carries complete tray to the service user. While approaching the patient robot provides him with information that it brought him water and medicine. The patient, who expected service, moves his hand to grab a glass but it seems weak and physically clumsy. Glass gets out of the hands, falls down to the floor and breaks. Consequently the water spills on the floor. The patient responds affectively (physically and mentally) in accordance with the feelings that are mixed: surprised, frightened and frustrated. Depending on personality traits and temperament his/her affective reactions can be very expressive, moderate or weak which can be appropriately defined in accordance with fuzzy logic forms. On the other hand, the robot carefully "observes" what happened. Based on the video stream from the stereo camera, sensor information from sensors attached to the patient (on the change of pulse, blood pressure and acceleration due to e.g. re-jerk reflex) robot finds out what happened (enabled by the cloud) and understands the context in which the event occurred. On the basis of the information made known in advance about the patient (personality type, temperament, medical indicators that preceded the event) the robot is expected to act in accordance with medical, social and ethical principles in a way that is desirable and beneficial for the older person.

In certain situations it is desirable that the robot has a complementary personality to the patient's personality profile of whom takes care of, to be tolerant, kind, devoted, full of understanding (supporting) for others, etc. In psychology, complementary personality types and temperaments which mutually agree are well known. In this sense, the robot was awarded traits that are desirable in a given situation. Cloud system as a global structure supports adaptive approach to building personality with robots. How to concretely embody (implement) certain attributes of personality in the robot will be shown through the following semantic table. Table links incentive event, personality type and temperament with output affective states. The meaning of symbols in the table is as follows: '+' increases the level of experience, '−' decreases, '++' and '−−' significantly increases/significantly decreases.

Based on semantic table given in Table 3 fuzzy rules of the model of affective behavior can now be applied for instance considering the case "broken glass".

Table 3 Semantic table—trigger versus affective state

Trigger event	E	I	Sg	Ch	Ph	Ml	Affective state
"Broken glass"	+	−	+	+	−−	+	Suprised
	+	−	+	+	−	++	Frightened
	+	−	+	++	−	+	Frustrated

If you introduce a degree of gradation among attributes of behaviors (e.g., et al., slightly, moderately, significantly, extremely) and introduce the membership functions in the form of Gaussian curves and then apply semantic rules defined in Table 3, the following fuzzy rules can be written. Derived scheme for writing rules also applies to other event that causes the same feelings of surprise, fear and anger with people. Derived rules have for example the form where 'PT' stands for personality type, 'TE' for temperament, and 'AS' for affective state:

Rule 1: if (PT = slightly 'E') .and. (TE = slightly 'Sg' .or. TE = slightly 'Ml') then (AS = slightly 'Surprised')
Rule 2: if (TE = moderately 'Ch') then (AS = extremely 'Frustrated')
Rule 3: if (TE = moderately 'Ph') then (AS = slightly 'Surprised') …

In the considered case the personality profile determines the intensity of affective behavior. Semantic tables and fuzzy rules are determined based on experience or on the basis of experiments performed on a number of subjects. The quality of tests performed (sincerity of respondents fully understanding the point of the matter) depends on the accuracy of derivative fuzzy model and it can be successively upgraded and further improve. The number of cases processed (in the field of application) in the database depends on the generality of the cloud model and its applicability to a broader set of tasks within the application. As shown emotional states in humans and robots can be numerically already estimated and expressed in percentages. It provides many other features not only application in robotics but also in medical diagnostics, therapy, stimulating the patient's motivation, etc. In a similar way the rule-base can be updated and completed to cover application.

6 Conclusion and Future Work

The paper presents results of research conducted with a goal to develop emotionally intelligent, social, service robot for care of elderly. The main novelties in this paper regards to:(i) original mechanical design of robot that allows better mobility of patients and meets ergonomic design standards, (ii) application-oriented cloud robotic system architecture, and (iii) development of robot EI-controller that enable personality embodiment and a better understanding of emotional and social behavior of patients. It ensures better social acceptability of new technologies.

The laboratory prototype shown in Figs. 6 and 7 will be built, tested and evaluated in typical household tasks, which should open up the possibilities for its commercial applications. Future work will be done with aim of improving technical performances: sensory-motor skill as well as extensive cognitive capabilities. Also, one of the most important tasks to be fulfilled in the future is to complete the data-base at the application level to give system more applicative freedom.

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