Care-O-botÔ: A System for Assisting Elderly or Disabled Persons in Home Environments

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Abstract – Medical expenses are increasing drastically all over the world. More than 30% of these expenses can be related to elderly people. By the year 2030 the number of 60-year-old people will have doubled. Technical aids are required allowing people to live independent and supported in their private homes as long as they wish. As a contribution to these required technological solutions a demonstrator platform for a mobile home care system – called Care-O-bot™ – was designed and implemented by Fraunhofer IPA, Stuttgart. The Care-O-bot™ is a mobile service robot, which has the capability to perform fetch and carry and various other supporting tasks in home environments. Main emphasis is laid on integrating communicational and social features, like video telephone, automatic emergency calls and other interactive communication. Focus of our work performed so far is the mechanical design and realisation of the vehicle, the development of the control system architecture, the implementation and testing of navigation and motion algorithms. The integration of a sensor guided robotic arm for fetch and carry tasks is part of the next development phase.

1. PRESENT SITUATION

In Germany, the number of 60-year-old people is expected to double, while the number of 90-year-olds will triple by the year 2030. Accordingly, the number of people with illnesses and restricted capabilities is also expected to increase. Statistics reveal that the number of persons requiring home health care in the year 2040 will make up nearly 3.5 % of the population (today it is 2.1%).

Significant savings occur when individuals who need support in daily-life-activities can continue to live at home, as high costs incurring form individual treatment in Senior Citizen Centres and in Nursing Homes are eliminated. According to an economical study performed in the USA more than 3 billion US dollar could be saved per year, if all elderly US-citizen would stay just three more months at home before joining a senior citizen home.
Beside new decentralised services supporting elderly people at home, accompanying technological solutions are required helping people to facilitate life at home.

2. BENEFITS FOR USERS AND COMMUNITY

Improving the quality of life for the elderly and disabled persons is becoming an essential task for society today. An important aspect for all people having the need to be supported in their daily-life-activities is to be still integrated into social life despite of their existing disabilities.

The focus for the immediate future and the following decades is to realise the principle ”home care before facility care” as already stated in existing care laws.

However, the financial strain on the country and the individual to provide this care is extreme, so the primary task for society will be to reduce the costs for care, while preserving and improving the quality of life for this group.

The resulting advances and benefits for elderly and disabled people applying technological aids – like Care-O-bot™ – are the following:

- Increase of personal independence,
- Improvement of quality of life,
- Strengthening and support of personal mobility,
- Active aid during absence of care personnel and nurses,
- Increase of individual security,
- Unified and easy handling and operation of home infrastructure through natural speech,
- Better social integration via video-phone,
- Reduction of medical costs for in-house care.

In the next years there will be a successive development of total and partial systems in the area of home help aids. Assuming that these systems will be used in environments in which the user has little or no technical aptitude, these systems must have the ability to adapt to its environment independently and focus on its main function: to be a constant aid for the person in need.

3. REQUIREMENTS TO HOME CARE SYSTEMS

Technical systems can give support and instructional help and also promote self-initiative. Therefore, a mobile service robot would support the following functions in an optimal case:

Household Tasks and Personal Supply

- Delivery and disposal of meals, food and drinks,
- Performance of simple household services - like cleaning or flower watering etc. .

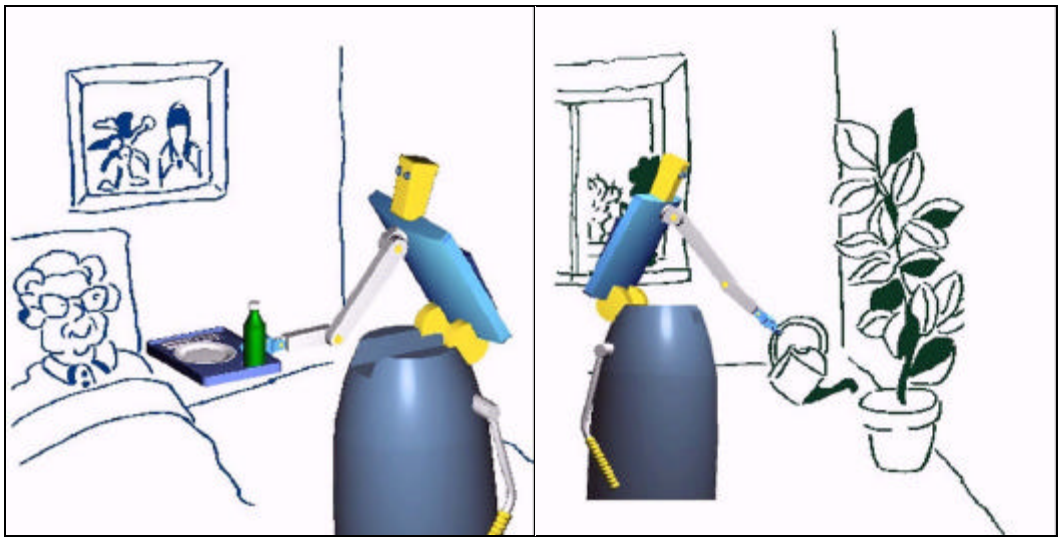

Fig. 1 Care-O-bot™ serving a meal to a person laying in bed or performing useful household tasks

Communication

- Communication with medical services and authorities (tele-medicine, doctors, etc.),
- Automatic emergency calls,
- Management of home media (video telephone, TV, music, interactive media etc.),
- Voice and Multimedia touch-screen as natural and intuitive command interface,
- Management of personal contacts.

Technical House Management (Infrastructure)
- Control of home infrastructure devices such as heating, air conditioning, lights, windows, front door, security / alarm system etc. .

Mobility Support
- Support and guidance assistance,
- Support for getting up from chair, bed etc., support as a intelligent standing and walking aid.

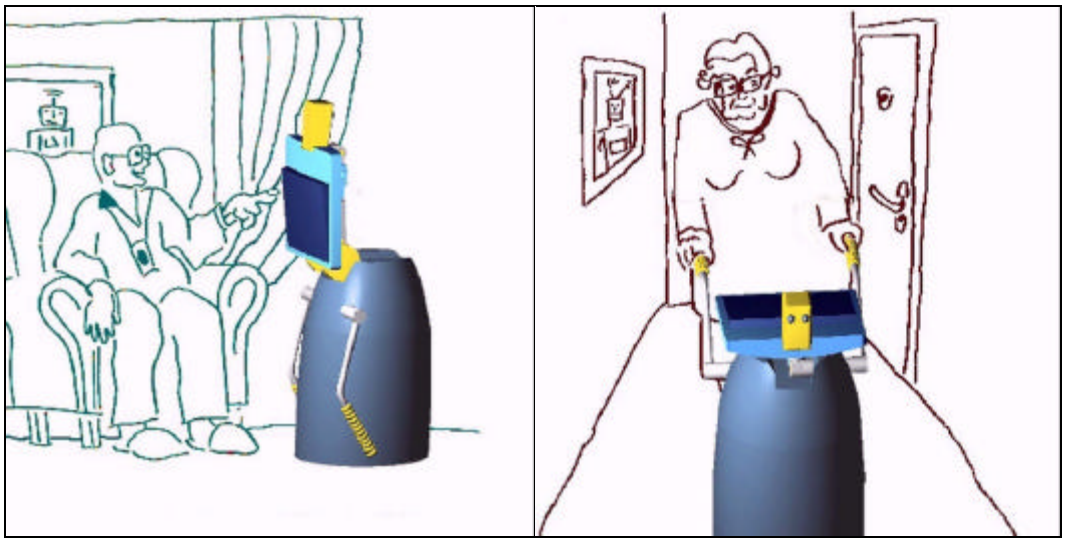

Fig. 2 Care-O-bot™ acting as communication platform or giving a helping hand as mobile walking aid

Handling Aid / Fetch and Carry Tasks
- Providing medicine, care products, laundry, books, remote control etc.,
- Support in grasping, and holding of objects and devices – as e.g. holding a book etc.

Personal Management and Social Integration
- Day-time-management (personal contacts, daily routine, medications, reminder to birthdays, fixed dates and events, activity motivation etc.).

Personal Security
- Monitoring of personal safety,
- Monitoring of vital parameters (pulse, respiration, blood pressure, temperature, etc.),
- Monitoring of mental parameters (behaviour, activities, responsiveness, etc.),
- Recognition of missing / critical life signals or abnormal daily routines and automatic call contact to neighbours, local services and / or authorities in case of emergency,
- Health management (information, advice, motivation).

4. SPECIFICATION OF TECHNICAL SOLUTIONS OF A MOBILE HOME CARE ASSISTANT

Taking the given requirements into account, the following technological concept was developed by Fraunhofer IPA:

Mechanical Concept
- Mobile platform suited for home environments – with limitation to a flat floor level – optional: elevator rides,
- Integration of a manipulating arm with flexible hand able to perform simple handling tasks like grasping, holding, serving, fetch and carry, etc.,
- Walking aid and standing up aid for disabled people,
- Integration of all electrical components.

Electrical Concept
- Independent, battery based energy management and supply,
- Automatic battery recharging,
- Interfaces for external instruction (remote control),
- Interfaces to home infrastructure.

Control System Hardware
- Modular and extendable control system hardware,
- Unified and standardised interfaces to various types of control components and sensors,
- Design to low-cost architecture,
- Sufficient hardware capacity for multimedia purposes and speech recognition.

Control System Software
- Environment recognition,
- Map building and dynamic path planning,
- Task, action and execution planning,
- Collision avoidance and obstacle surrounding,
- Reactive navigation and dead reckoning,
- Force feedback control in walking aid mode.

Operator's Interface
- Instruction of Care-O-bot™ with natural speech,
- Answers, announcements and provision of information in natural speech,
- Alternative instruction and provision of visual information on touch screen,
- Video-telephone connection.

5. CONTROL SYSTEM ARCHITECTURE

To fulfil and perform all required functions of Care-O-bot™ a sophisticated control system is necessary. While designing such a suited control system architecture the following aspects and technological needs have been taken into account by Fraunhofer IPA:

Technological Needs of Control System:
- Manual remote control of Care-O-bot™ (optional),
- Central disposition of several Care-O-bot™ – e.g. in a nursing home (optional),
- Natural speech control interface and visual touch screen commanding,
- Multimedia touch screen for information visualisation and manual instruction,
- Sensors for environment recognition, map building, collision avoidance,
- Drive control of motion axes, rotational body axes and manipulating arm,
- Modular architecture for future extensions,
- Control of supporting electrical devices – like mechanical bumpers, battery charger etc.

The resulting control system architecture has the following technical characteristics:

Resulting Control System Architecture:
- Master PC for vehicle control with RT kernel VxWorks for instructing all device and drive control modules,
- Modular field bus network based on CAN-bus allowing to easily connect various types of decentralised control modules – e.g. for axis control, sensor data evaluation etc.,
- Various types of operation modes driving the Care-O-bot™ according to the needs of its usage – as e.g. automatic, manual and reactive mode,
- Connected sensors for navigation are: CCD-camera, high-resolution 2D-laser scanner, segmented mechanical bumper and position measuring wheels,
- Secondary PC, connected via Ethernet, running under Windows NT/95, being responsible for the control of all communicational tasks – like speech control, multimedia touch screen, video-telephone, external instruction and linking via wireless Ethernet connection.

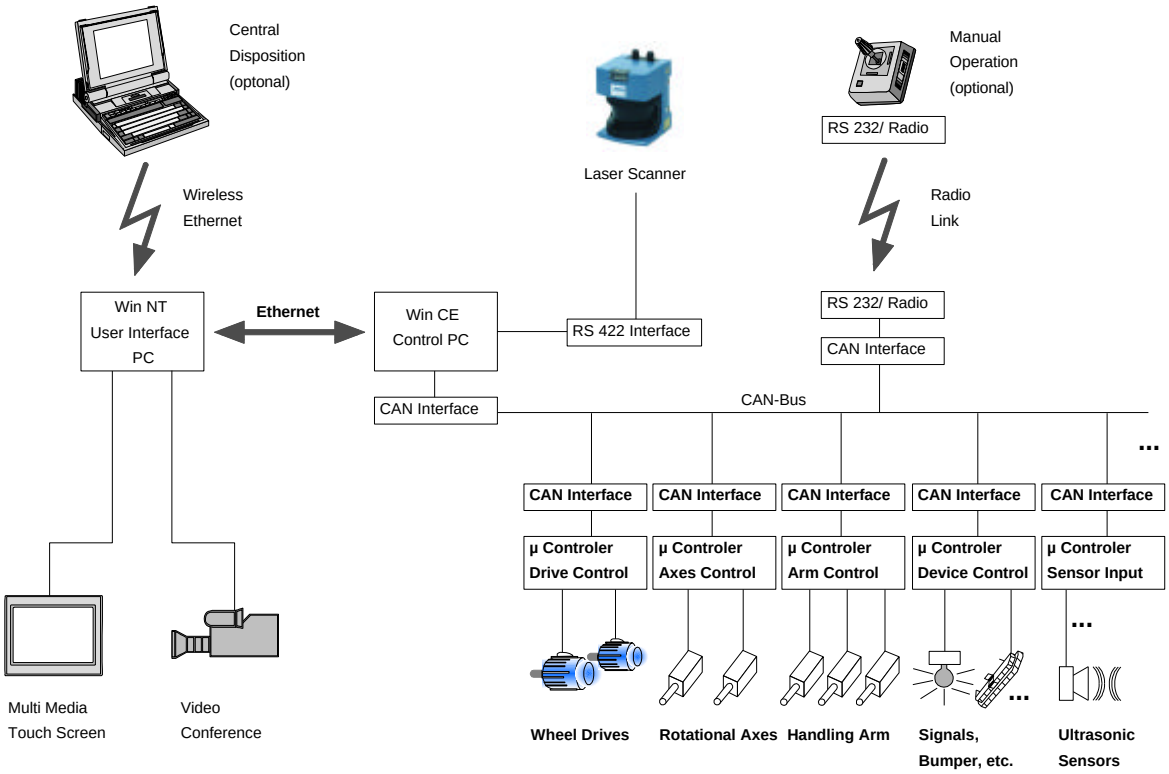

Fig. 3 Care-O-bot's™ decentralised control system architecture

6. PROTOTYPE REALISATION

The prototype system of Care-O-bot™ – as shown in figure 4 – was integrated, tested and optimised by Fraunhofer IPA in Stuttgart. It was successfully presented the first time to the public at the Hannover Fair, in April 1998. On the basis of the very promising demonstration results and the given feedback from both customer and supplier side, the technological concept of Care-O-bot™ will be further developed and integrated at Fraunhofer IPA in close cooperation with related industrial partners and professional care service organisations. The next step in technological development at Fraunhofer IPA will be the implementation and integration of a supporting manipulating arm into the mobile platform. The first simulation tests with various arm types have been performed yet – with encouraging results.

Fig. 4 Integrated Care-O-bot™

7. CONCLUSION AND OUTLOOK

Due to the given demographic trends and developments within the industrial societies all over the world practical solutions are required that help to dam exploding medical costs. Besides new decentralised supporting services for elderly and disabled people living longer at home, new technological solutions are required to facilitate their daily life.

With the developed concept of an intelligent Care-O-bot™ an interesting solution is available that allows to further facilitate and enable the secure living of elderly people at their private homes under safe conditions – according to their own wishes. Nevertheless the underlying technological concept of Care-O-bot™ is not limited to applications in health care. Further possible applications of the Care-O-bot™ concept are:

- ”Personal robot” in private homes (”robotic butler”),
- Mobile information desk in public areas,
- Robot valet,
- Safety guard,
- Robot receptionist in office buildings,
- Guided robot tours in museums,

etc.

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