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Pandemic Robot

A concept for robot-based surveillance of inhabitants in elderly and nursing homes during pandemic situations

Abstract: Robot-based service platforms are currently establishing themselves as new and affordable variants for supporting care in elderly, retirement and nursing homes. Many are open multifunctional platforms, which can potentially be integrated into such environments, if the necessary infrastructure is available. Furthermore, many services can be realized on these platforms, which can be used to foster distant interactions between inhabitants and care-providers, while simultaneously keeping up the quality of life of the inhabitants.

Open mobile robotic platforms allow the extension with adequate new sensors. To detect infectious diseases of residents and healthcare-professionals, optical sensors can be used for the assessment of vital data such as heartrate and heartrate variability, respiratory rate, SpO₂ or temperature. Additionally, you can consider demographic data (age, gender, constitution) of the observed person for the optical assessment, i.e. obtained by facial image analysis.

As these mobile platforms are also equipped for telepresence, in case of detecting an infected person, these systems support video conferencing with their built-in cameras and microphones. Finally, the interaction with the electronic care record is necessary to upload all acquired vital data and further relevant information.

All the named technologies have been under investigation in the past years and are currently moving from laboratory settings to real-world scenarios. Nevertheless, the smooth integration of all components into one system architecture in combination with (AI-based) data analysis are still open issues.

Keywords: Robotics, AAL, Care, Smart Living

<https://doi.org/10.1515/cdbme-2021-2153>

1 Introduction

The Covid-19 pandemic creates several challenges to our society. One among others is the necessary reduction of overall contact situations to avoid infections. Therefore, the question arises, if, how and when robots can replace or reduce people's direct interactions to limit such infection risks.

The field of service robotics exists for more than 20 years and there have been continuous researching activities in this domain. Usually, the specific focus of most of these efforts is to optimize the collaboration possibilities between humans and robots [1]. Even though autonomous robots and mobile service platforms have been applied and investigated for many different applications in the field of home care as well as retirement and elderly homes [2, 3] current research projects have not yet shown promising examples for service robots in real world scenarios with complex interaction tasks. Furthermore, autonomous robots are costly in terms of the investment as well as the preparation of their future working environment and will thus potentially reduce the users' acceptance. This investment paradigm has changed with Covid-19, coupled with the necessity to reduce the interaction between humans (inhabitants, relatives, nursing and medical staff) in the same room. Moreover, a strong need has been established to recognize potentially infected persons, and thus reduce the risk of further infection chains.

In this contribution, we describe our concept and approach to fulfil the above-mentioned necessary steps to add useful sensors to existing mobile robots to detect pandemic-related situations. Moreover, we propose other use cases related to these robots to address Covid-19-management related requirements with the user or tenant in mind. As an indicator for the evaluation of our approach are Quality of life measurements [4].

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Figure 1: Categories and subcategories of the relevant terms of the robotic and service robotic domain [5,6].

2 State of the art

There exist several categories of mobile robots (see Figure 1). For this paper, the retail and commercial robots among the service robots are especially relevant. Almost all of their subcategories and fields can be addressed by the robot platforms.

Common robot platforms are becoming more and more interesting for commercial and retail clients. Three common examples of such robot platforms are Pepper, Sanbot Elf, and Temi (see Figure 2). The investment costs for these platforms are currently decreasing from around 15000 EUR (Pepper) over 8000 EUR (Sanbot Elf) to 5000 EUR (Temi). Moreover, technological progress brings more robust systems and shorter software update cycles, two very important aspects when it comes to users' acceptance. There is still a lack of commercial-friendly support packages, which are necessary for professional clients because they often assure service-specific agreements with their clients. Several sensors are part of these robots (see Table 1).

Recent research shows that the use of social robots, such as the Pepper [7], QTrobot, or Sanbot devices, can be very beneficial in the communication with inhabitants in elderly and nursing homes. The robots support simultaneously the social impact while having the possibility of carrying various sensors for remote sensing of vital signals such as temperature, heart rate, heart rate variability, respiratory rate or SpO2.

In the past years, various methods of remote Photoplethysmography (rPPG) have been proposed for the contactless, optical assessment of the heart rate (HR) and heart-rate-variation (HRV) [8-10] with applications in the field of ambient assisted living (AAL) or smart home care. Similarly, there have been investigations to combine the

Figure 2 Sanbot Elf, Pepper and Temi as examples for common mobile robot platforms.

possibilities of optical assessment of vital parameters with mobile platforms, such as robots [11, 12].

To determine measurements that help to make pandemic specific decisions other sensors are necessary and helpful. Usually, such sensors can be added to the peripherals of the robot. Summing up, service robots and external sensors seem promising to help in pandemic specific situations.

Table 1: Overview of attributes of three different communication-based robots, here Temi, Sanbot and Pepper.

Attribute	Sanbot Elf	Pepper	Temi
Dimensions	902 x 421 x 331	1200 x 485 x 425	1000 x 350 x 450
[mm] (H,W,D)			
Weight [kg]	19	28	12
Costs [€]	Ca. 5.000	Ca. 15.000	Ca. 5.000
Speed [m/s]	0,8	1,39	1,0
Uptime [h]	10	12	8
Touchscreen	Breast-height	Breast-height	Head
Camera	2 RGB camera	2 HD cameras	2 depth cameras, 1 RGB camera
3D	3D sensor	3D camera	360° LIDAR
Microphones	7	4	4
Touch sensors / tactile sensor	12	5	
Distance sensor	15 infrared	6 laser 2 sonar	5 distance-based
Gyroscope	X	X	
Miscellaneous	Compass		IMU sensor 6 ToF sensors

3 Challenges

During the Covid-19 pandemic, in nursing homes, clients had to suffer from isolation and an enormous risk to die. Thus, potential robot platforms, which shall be integrated into such nursing and retirement homes, need to be affordable for the facilities on the one hand. On the other hand, the mobile platform needs to open to carry additional remote optical sensors, which can be placed onto the robotic device. Furthermore, to enable communication services for the user, the system needs to offer robust and easy-to-handle audio-visual communication tools and services, for example, to start a telemetric consultation session with a physician. Thus, there exists a high need to specify the most relevant use cases for such social and service robots precisely, that it will be possible to choose the best fitting devices. Relevant use cases are:

- The robot identifies a specific person and automatically initiates the vital data acquisition for this person.
- The user and/or the physician can initiate a remote video conference or consultation by using the robot.
- Based on acquired vital data the robot automatically informs relevant stakeholders appropriately, if a possible infection of a client occurs.

In order to be automatically initiated, these use cases additionally need to determine the correct context, for example to detect the robot and user's position or to create a strategy to find the best walkthrough through all of its daily tasks. Furthermore, the robot will benefit from a seamless integration in the connected environment to confirm its own conclusions about the proper actions [13-15]. The acquired data from the connected environment is often necessary to figure out how to adjust the sensors or camera positions or just to open doors remotely to get into a room.

4 Approach

At our institutes, several platforms are available and we tried to evaluate, how promising these platforms are to fulfil such complex tasks like helping in Covid-19 detection and corresponding management. First, we use a mobile robot, here Temi and added some sensors, here cameras to its periphery. The Temi is connected to the environment with a smart home middleware system, here openHAB. The mobile robot drives through hallways and can send sensor signals to openHAB and get relevant information from there and from the C&S cloud backend application as well, i.e. care related process data. Therefore, it is possible to improve context awareness, which

is necessary to distinguish between people and identify them. The robot will be able to acquire health related, pandemic relevant data contactless and autonomously. If any problems arise specific partners will be alarmed, i.e. the physician after a positive test result (see Figure 3).

Figure 3 Concept overview.

5 Results

The following list summarizes the experiences and lessons learned with respect to the addressed task, enhancing a service platform or social robot towards a Pandemic Robot:

- Pepper was not a good foundation for a pandemic robot, as the built-in camera was not able to acquire image data for heart rate detection. Moreover, Pepper's ROS interface is hard to interact with and the robot asks for a break after a short amount of time due to hot joints.
- Sanbot has not performed well enough as a foundation for a pandemic robot, i.e. the positioning tasks for following people to specific locations cannot be managed appropriately, especially because the Sanbot Elf cannot turn precisely enough. Furthermore, the Sanbot Elf is based on Android, so it is important that the operating system and the vendor specific library is updated regularly. Sanbot Elf Android OS have only been updated once per two years and so after a while many conflicts arise between Android Studio, Android OS on Sanbot Elf and the vendor specific library to access the internal sensors and cameras.
- Temi seems to be the best candidate to enter the market due to its improved robustness, low price and overall performance.
- For automated and robust heart-rate and heart-rate variability detection, constant lighting environments are essential, which makes the solid context awareness essential to improve the necessary users acceptance. The context awareness can be improved by integrating the robot in a smart environment.

- The built-in cameras and sensors are not all capable to acquire the raw data and are not always offering an adequate API to get the relevant data for processing.
- In order to design and build adequate modules for contactless optical vital data, large-scale image sequence collections with reference data are needed. These are currently hard to obtain as facial data carrying the information about the vital signs cannot be anonymized and need the written consent of the depicted persons.

We decided to describe and show our approach to 10 experts (scientists, professionals) and interviewed them. Core aspects that need to be improved are to minimize the effort for the elderly when it comes to data acquisition. Camera-based approaches lead to privacy-related challenges, especially if raw data needs to leave the local network. Therefore, we will extend our approach to address these challenges appropriately and simultaneously a survey with people of the target group has been started. The experts have rated the overall concept of a pandemic robot as “highly relevant”.

6 Discussion

Service and social robots will be able to create benefits in the care sector, especially when pandemic situations arise. The main advantages are that they can decrease the risk and the necessary amount of contacts. Anyway, many more challenges exist to operate service and social robots in elderly care. The tenants, clients, and caregivers are not used to high-tech devices like robots and so the first unexpected reactions will reduce users' acceptance. Due to the current experiences, we expect to see service and social robots in real-world scenarios in 3 to 5 years.

Author Statement

Authors state no conflict of interest.

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