Ambient Assisted Living for Type 2 Diabetic Patients

N. Bal and M. Schwarz
Niederrhein University of Applied Sciences
Reinarzstraße 49, 47805 Krefeld, Germany
nefisebal@hotmail.de and markus.schwarz@hsnr.de

***Abstract* — As a consequence of the demographic change innovative technical solutions are required to enable elderly and chronically sick patients to have a safe, autonomous and self-determined life. Therefore in this contribution we propose different modules to customize "Ambient Assisted Living" (AAL) environments for patients suffering from diabetes mellitus. Since diabetes is a general term for a range of metabolic diseases, all leading to an increased blood glucose level (hyperglycamea), different technical assistance systems will be discussed, including diagnostic, preventive and therapeutic modules. The proposed modules have been analyzed and selected to both assist diabetic patients and prevent them from concomitant diseases and therefore reduce further deterioration of their health.**

Ambient Assisted Living; type 2 diabetic patient; technical assistance systems (key words)

I. Introduction

The trend with regards to social change in our society is evident: we can observe an increased expectation of life, regression of birth rate and a further call for individualization. As a consequence the number of elderly and single people is continuously rising. Based on this tendency it is obvious that new services supporting the elderly and aiding them in their orientation are required. Innovative solutions have been proposed and partially implemented to facilitate a safe and autonomous life especially for elderly and sick persons frequently suffering from chronic diseases. Services that have been developed in this area include cardiac and general mobile monitoring systems, which up to now are not fully integrated in AAL environments. Since the term AAL comprises new concepts, technical products, services, logistics, new technologies, and social environment, with the aim of increasing the quality of life, safety and care for patients of all age groups, this integration process is a complex task, in particular when also a reduction of costs for the health sector is requested [1]. Because no other health threat has been spreading as rapidly as diabetes mellitus, where six million citizens in Germany are affected by this chronic disease, we have decided to focus on customization of AAL platforms for type 2 diabetic patients. It is expected that the number of diabetic patients will increase to 12 million until 2018, thus creating a true challenge to offer competent and cost efficient care for the elderly in their home environment [2].

Diabetes mellitus is defined as a metabolic disorder with raised blood glucose levels. Chronic hyperglycamea can lead to long-term damages, functional disorders and failures of various organs (Fig. 1), in particular eyes, kidneys, nervous system, brain and vascular system [3, 4]. Thus technical systems that adapt AAL for the type 2 diabetic patient, in the first place, has to assist the type 2 diabetic patients in their home environment in an unobtrusive manner and also protect him from secondary illnesses and emergency situations. Several diagnostic, therapeutic and preventive modules have been selected for this purpose and will be discussed below.

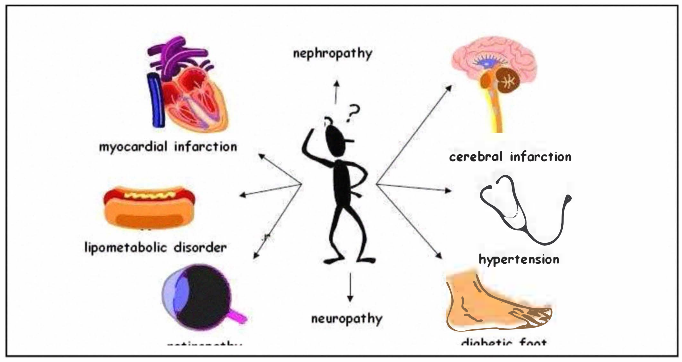

Figure 1. Secondary illnesses

II. Possible technical assistance systems

Systems proposed for the type 2 diabetic patient in his/her home environment, currently not integrated into AAL systems, include measurement of blood microcirculation, modules for prevention of a diabetic foot, intelligent drug cabinets and interactive sport and balanced diet assistants. Fig. 2 illustrates how this system is subdivided into the categories diagnostic, preventive and therapeutic modules, in relation to their medical importance. Besides of a user-friendly implementation, each system is discussed in relation to its cost and feasibility.

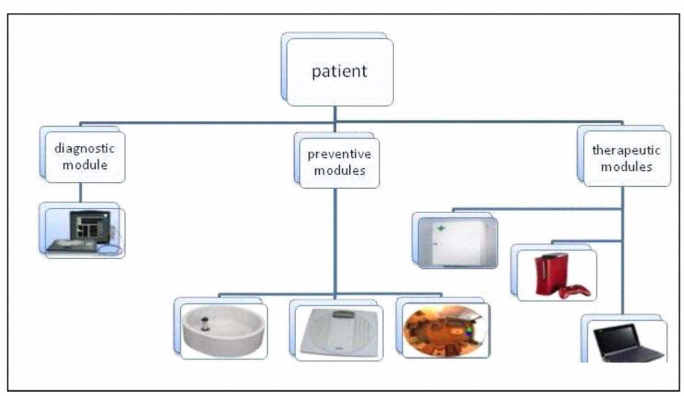

Figure 2. Possible technical assistance systems

PERVASIVEHEALTH 2010, March 22-25, Munchen, Germany

DOI 10.4108/ICST.PERVASIVEHEALTH2010.8815

A. Diagnostic module

1) Measurement of microcirculation: The noninvasive measurement of the blood circulation with the help of the laser doppler spectroscopy serves as diagnostic module for different diseases with micro and macroangiopathic consequences. Among these, inter alia, the peripheral arterial obstructive disease and the diabetic foot syndrome are most important. Using miniaturized laser modules it should be feasible to integrate a measurement zone inside an electronic scale or in front for either the washbasin or toilet. This enables us to perform unobtrusive noninvasive measurements of the blood circulation during personal hygiene several times a day. The method of the laser doppler spectroscopy is based on recording the movement of erythrocytes. Near infrared light with a wave length of 820nm is applied to the foot directly or through an illuminated fibre. The laser light penetrates the skin (in future possibly also thin stockings) and enters the tissue. The motile erythrocytes diffuse the light and shift its frequency. The laser Doppler flowmetry (LDF) systems photodetector array finally detects the shift in frequency of the backscattered light, thus the illustration of the blood flow in various measurement depths is possible. The corresponding depth reflecting the laser radiation is influenced by different components, e.g. the geometry of measuring probes, the measuring position and the skin type. The exact calculation for establishing the individual depth of detection though is marred by the individual composition of the tissue. Ignoring and optimising these influencing factors when recording the depth measuring a tissue depth of 2, 4 and a maximum of 8 mm, is feasible [5].

Actually available modules need several seconds up to several minutes for flow measurement including system warm up time. The acquired data is sent to the AAL system to customize its behaviour and to a physician who has access to the secured collection of data. Hence a process analysis for micro and macroangiopathic diseases can be carried out. The diabetic patient is informed by telephone if his/her medical condition is worsening and necessary steps can be taken. Additionally the patient is advised in a follow-up contact on relevant procedures to improve his/her health.

B. Preventive modules

1) Foot bath: Particularly for the prevention of the diabetic foot, a special basin is installed in the bathroom. The basin comes with a seat, which is fixed to the wall. Furthermore the basin has a multifunctional shower head and control units for water temperature and flow, optimal for washing the diabetic feet. The shower head contains care products, incorporated into specific areas, such as soap or lotion. The foot basin also has a built-in timer, so that the recommended washing length for the feet can be regarded. The foot basin, despite of its simpleness, significantly enhances the phrophylaxis of the diabetic foot. Fixing and mounting the multifunctional shower head requires some extra effort, but should not be a problem for a plumber when following the instructions given. There are mainly acquisition costs for to built-in components, such as foot basin, seat and shower head.

2) Intelligent electronic scale: The aspect of weight is very important for the diabetic patient, because a continuous reduction of weight helps the diabetic patient to reduce the risk of secondary diseases or co-morbidities. Therefore the installation of an electronic scale in the bathroom is beneficial. The electronic scale is also built into the floor in front of the washbasin. When standing on the scale barefoot, the weight, fat and water content of the body is analysed. Mounting and interfacing this intelligent scale to the AAL infrastructure by internet protocol (IP) is not problematic but requires some extra effort. Installing the scale in the floor is evident, since it prevents the patient feet from lesions in daily use.

3) Intelligent room: Developments in the technical field show a rising need for a wide range of concepts and devices in the area of telematics. They offer modern solutions for supporting patients in their home environment. Here the intelligent room is of particular importance. The intelligent room as described in [6] is a home based automatic system which supervises patients, focussing on recognising potentially dangerous situations. When the state of the patient's health seriously worsens, appropriate measures are initiated, so that emergency situations are prevented [6]. There is room for improvement with regards to NIR and 3D time of flight (TOF) 3D camera systems. So far conventional 2D fish-eye cameras only record 2D-pictures, which not always provide enough information for examining body movements, active 3D camera system could fill the gap and are also less sensitive to variations in room illumination. So the recommended solution is a 3D TOF camera based body motion analysis system. For automatic analysis of the acquired data, discrimination of quasi stationary objects (furniture) and the patient is required, and can be implemented by differentiating motion patterns (long time without lateral movement followed by abrupt movements for the room inventory vs. more frequent, twisting and continuous movements of the patient). In a similar way the patients motion itself can be analysed to distinguish different physical states, if permitted by the patient. An intelligent room equipped with this type of camera and motion analysis will be well suited for detecting emergency situations, thus is a very significant technical assistance system. Since pulses laser modules for active illumination and high speed shutter cameras are available, TOF systems are affordable as a principle components for a future intelligent room.

C. Therapeutic modules

1) Drug cabinet: A further technical assistance system is the "intelligent" drug cabinet as proposed in [7]. It is able to automatically distribute the prescribed medication on time but does not control the intake. Thereby it can reduce the risk of unintentional overdosage and dangerous combinations. Cleaning will not be necessary because of its silver-ion-coating, which is known as a standard disinfection agent. However a manual weekly refill is necessary. Though the patient can benefit significantly, this concept is not yet available on the market for the general public but has been proposed in [7]. Prior developments include mechanical and acoustical sensors for dosing and monitoring drugs, integrated into the one-way package itself, but failed due to the

Digital Object Identifier: 10.4108/ICST.PERVASIVEHEALTH2010.8815
http://dx.doi.org/10.4108/ICST.PERVASIVEHEALTH2010.8815

additional costs. Hence the approach of an intelligent multi drug cabinet is promising.

2) Sports programme: Next to an appropriate diet, exercising is one of the most important aspects of the prevention of diabetes mellitus. Therefore the development of a specific exercise program for diabetic patients is useful and has been described in detail in [7]. The main prerequisites are exercises appropriate for patients affected by diabetes and high efficiency in assisting the patient in losing weight. The exercise program kit contains a camera and a game console, including relevant exercises. This kit offers sensors and actuators the patient needs for exercising. The exercise hard- and software can also be adapted to other diseases and it can be used as therapeutic and also diagnostic module. Its major advantage is the examination of all movements of the body and their recording so that execution can be corrected and analysed by an assisting therapist, if necessary. It can be concluded that the sports module can act as a stimulus for exercising at home, but will not replace an overall exercise program for diabetic patients.

3) Electronic cooking device: An appropriate diet is the basic therapy for type 2 diabetes. Therefore an electronic cooking device as a possible technical assistance has been proposed in [7]. In consultation with a nutritionist the electronic cooking device helps the patient to comply with dietary requirements and preparing the food. This small electronic device is portable, has a touchscreen and optional voice control as well as a dirt repellent display. During cooking it can be securely attached to kitchen equipment. Basic recipes for diabetics are preprogrammed, others can by loaded from external servers. Both are presented as video sequences and assist the patient in the process of preparing meals. The user can choose dishes she/he favours, as regional or international choices are available. Further this electronic device is able to exclude dishes, using ingredients the patient cannot tolerate, for example allergenic ingredients or ingredients currently not available. The system knows about available stocks from the intelligent fridge and RFID equipped cupboards if established in future. An appropriate menu navigation will solve the problem of video sequencing each cooking step with the help of simple visual and auditory multimedia technologies. A joint collaboration of nutrition experts and computer scientists facilitates the visual presentation of specific dishes.

III. Conclusion

Technical assistance systems integrated into the bathroom area have been described, including blood circulation and automated weight measurement. Measuring microcirculation is possible with the help of the laser Doppler spectroscopy, enabling the noninvasive presentation of blood flow in the micro vascular system. The measuring instrument will be integrated into the floor or inside an electronic scale. A further concept is the foot bath. Installation of such a foot bath and its necessary components helps preventing the diabetic foot. All provisions aiming at preventing the diabetic foot are considered. Intelligent room concepts have been extended and will strongly benefit from 3D time of flight camera systems which also are less sensitive to changes in room illumination and equipped with motion analysis. Combining these unobtrusive technical aids with the proposed sports and cooking assistant, the AAL system has been customized for patients suffering from type 2 diabetic, in a manner that should provide high patient acceptance.

IV. Outlook

Future technical assistance systems, not only for the type 2 diabetic patient, aim at improving quality of life and care in the home environment. Thereby some of the newly developed systems are also useful for patients with other diseases. Particularly with regards to the future, the intelligent room can be seen a revolutionary concept. It should improve the quality of life of users in the near future by integration of additional sensor systems. Invisible implantable sensors and hidden sensor systems in combination with 3D cameras will monitor vital parameters as well as physical and mental states. Although discussions on data protection and privacy will continue, a surprisingly high number of users is willing to accept and use such systems as long they don't have to wear special equipment. Concerning supervision, it is still under discussion in which scenarios a human supervisor can be replaced by a virtual supervisor and how to detect when to fall back to human supervision. Thus the continuous work of organizations in the field of AAL, telemetry, logistic,medicine and engineering is essential to optimize and integrate the mentioned technical assistance systems in the future.

References

[1] Ambient Assisted Living Deutschland: Ambient Assisted Living Deutschland. URL: http://www.aal-deutschland.de

[2] Diabetes Deutschland: Diabetes Deutschland. URL: http://www.diabetes-deutschland.de

[3] U. Gerlach, H. Wagner, W. Wirth, W. Domschke, B. Högemann, and A. Horn, Innere Medizin für Pflegeberufe, vol. 6. Stuttgart: Georg Thieme Verlag KG., 2006

[4] H. Hauner, Deutscher Gesundheitsbericht Diabetes 2009. Kassel: Kirchheim Verlag + Co. GmbH., 2008

[5] M. Ghazanfari, L. Vogt, W. Banzer, and U. Rhodius, "Reproduzierbarkeit nicht-invasiver Durchblutungsmessung mit der Laser-Doppler-Spektroskopie," Phys Med Rehab Kuror 2002, 12th ed., pp. 330-336, 2002

[6] J. Spehr, Beaufsichtigung von Personen im häuslichen Umfeld: Grundlagen und Konzepte zur Verwendung einer Fischaugenkamera. Saarbrücken: VDM Müller, 2007

[7] N. Bal, "Information technology concepts in intelligent room and building systems within the health sector," Diploma Thesis, 2009.

Digital Object Identifier: 10.4108/ICST.PERVASIVEHEALTH2010.8815
http://dx.doi.org/10.4108/ICST.PERVASIVEHEALTH2010.8815