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CapWalk: A Capacitive Recognition of Walking-Based Activities as a Wearable Assistive Technology

"CapWalk: A Capacitive Recognition of Walking-Based Activities as a Wearable Assistive Technology" presents the impact of wearable technology on elderly and pathologic conditioned patients. It describes the history of capacitive sensing and how advancements in this technology helped create a walking detector in a mobile context.

The research conducted through this paper mainly describes the benefits of having this technology available for the elderly and patients with pathological conditions. The researchers approach using capacitive loading more to create CapWalk, a device that uses sensing technology to detect walking activity.

Modern capacitive sensing was initially proposed by Whalen et al in 1993, his initial approach demonstrated that by "applying a single capacitive sensor the system was feasible in distinguishing between walking speeds" [1] between different activities, his research proposal showed new applications possible with this technology.

Whalen research was further investigated by Henning et al, his research proposed a method of "measuring the vertical contact stress beneath the human foot", enabling gait analysis while walking and running "by applying an insole with 499 piezoelectric sensors" [1]. The approach chosen for CapWalk is to use capacitive sensing to detect different walking styles in a mobile context to be used by elderlies and patients with pathologic conditions

Three prototypes were created to "demonstrate the feasibility of capacitive sensing as a mobile environment" [1]. These prototypes were created to be discrete but still offer the versatility of the technology. Thirteen (13) distinct participants were selected to perform different walking styles on a treadmill and cycle in an exercise bike; this was done to better simulate the distinct walking style performed by elderlies during daily activities.

Critical Evaluation

I found CapWalk prototypes to be creative and convey their approach in different real-world scenarios. The *Chest Band* is a chest belt made of electrode fabric being integrated with an OpenCapSense board to be worn underneath normal clothes with direct skin contact or atop of garments. The *Shoe Insole* is an insole that contains "six copper plates distributed on different spots" and is made to be used with everyday shoes. The *Leg Band* is a copper-based device containing a loading mode sensor that detects precise leg movement, precise walking speed, and precise caloric consumption.

All tests performed in these experiments show inaccuracy signs if directly compared to the prototype description.

All thirteen participants did not reflect the desired age group discussed throughout this research, this created inaccuracy issues as they could only simulate walk styles but lacked data from elderlies which was their primary focus group.

Furthermore, two prototypes showed stunning malfunctioning errors during the testing procedures, the chest band prototype was not worn with direct skin contact but rather "mounted slightly over the belly"[1] and it was required to be always wired to a computer system, this makes results inaccurate as it lacked both direct skin and mobile capabilities testing. The shoe insole prototype required to be placed inside the participant's shoe or a prepared shoe if the insole had size-related issues, this makes the testing results inaccurate as it lacked testing directly with shoes normally worn by the elderly compared to fourteen pairs typically worn by adults in an exercise environment e.g., using the treadmill or exercise bike.

I found the Assistive scenario section to be interesting explaining CapWalk benefits in real-world scenarios. All four scenarios show possible theoretical situations usually faced daily by elderlies and patients with pathological conditions.

The stress level detector uses leg movements to recognise personal stress levels while walking or driving the car, I like this scenario as it warns the elderly user relatives if they are shaking their legs unconsciously allowing immediately and lifesaving support depending on the situation.

The Health Monitoring notifies elderlies and ill patients with certain motivational or engaging messages if they stay inactive for a certain period resting or sitting on a desk. I liked this feature as it prevents long stagnation periods even if they are unconscious as this can lead to serious possible health complications.

The Anomaly Detection uses an insole to identify "abrupt loss of pressure that persists over time" [1] in both usual and usually daytime hours, identifying as an anomaly or a possible fall. I liked this feature as life-threatening falls daily occur for the elderly even away from public eyes, applying possible precautions beforehand can save many lives.

The Workout Performance offers accurate performance measuring features that are also used in a professional environment. It contains a very accurate step counter that provides information about step length, step speed, and steep angle. I like this feature as it provides useful information about their daily activities while also motivating them to strive to get better results.

Possible Improvements

All the CapWalk features described in the assistive scenario sections is no longer unique for this product as it's a staple in nearly all modern smartwatches. When this research paper was released in 2015, smartwatches was still a novice technology for the masses and lacked many fitness functions users use daily.

Recent smartwatches fitness features provide better precision detecting stress level as its position is atop of the left wrist pulse, and its step counter also provided more features unavailable for CapWalk such as blood oxygen levels [3], activity-based on certain parameters [4] and others used by both adults and elderlies daily.

It's recommendable that CapWalk researchers implement these features while also researching future improvements because a large percentage of elderlies does not have direct access to smart devices that provide these useful and possible life-saving features.

Currently, the participants of this research do not reflect their approach to this technology. Its gender ratio " 13 participants (including 1 female)" [1] is abhorrent as walking-related injuries vary between genders and age groups. Increasing the participants to 20 or more people aged 50-70 with an equal ratio of males and females will better reflect the challenges faced primarily by them, while also collecting data for future improvements.

External Research

The 2019 released paper “Multidimensional Capacitive Sensing for Robot-Assisted Dressing and Bathing “ encloses how PR2 robots are being trained and used to provide elderly and disabled patients by aiding them to get dressed and bathing them both in hospitals and homes, and how advancements in capacitive sensing robotics assist them in such important self-care activities.

Recent US Census Bureau data projects that by 2030 more than 20% of the current population will be aged 65 +, with 40% of them reporting facing a form of disabilities currently. It also conveys that people receiving home care report receiving help with dressing and bathing compared to other vital activities.

Their robot configuration uses “multidimensional capacitive sensing” to precisely estimate the surface of a person limb. The implementation approach represented in this research uses a "capacitive sensor mounted on the end effector of a mobile manipulator"[3] that consist of 6 conductive electrodes connected in a neural network trained in assisting people dressing and bathing.

Current sensing technology used for bathing and dressing uses outdated techniques that influence patients during these activities but lacks direct support for these self-care activities. Sensing devices previously used for this purpose (pressure mats, force sensors) still uses pre-2010's capacitive technology methodologies being highly outdated currently in 2022 e.g., Xbox Kinect camera [2].

The testing performed for this research was unique. They first tested the PR2 robot capabilities with different lateral and vertical angles between the end effector board and the patient closest limb position, it implied that the collection was used on the robot neural network allowing better precision on both in testing and real-world scenarios.

Other tests mainly focused on the PR2 robot abilities regarding dressing and bathing different patient limbs. The PR2 robot uses capacitive sensors to perform feedback actions to participants angled movements during the dressing phase. The PR2 robot also uses capacitive sensors to carefully bathe participants kept shifting their limbs in different angle positions.

I found the topics discussed throughout this paper to be very interesting and useful in modern health care. This research mainly conveys how healthcare science is aiding elderlies and ill patients to experience daily activities without feeling like a burden or alone which is highly common here in England.

Conclusion

Writing this e-health report seriously expanded my horizons on the importance of health care in recent memory. The CapWalk research shows the challenges elderlies faces daily to perform basic walking activities, and how device using capacitive sensing technology can seriously improve their quality of life and potentially save their lives.

My external research shows the challenges elderlies faces to bathe and dress in normal clothes. With the implied statistic from the US Census Bureau, a large number of adults are or will face disability issues in their daily lives. It's heart-warming to learn that recent technology advancements will facilitate this key task for them allowing them to retain their routines without major changes.

I had a great-aunt that faced both issues described through this report through her elderly age. In 2009 she was seriously hospitalised twice: on 03/2009 she broke her arm by trying to put on a shirt without her carer daughter, and in 10/2009 she fell from her chair trying to pick a spoon on a nearby table both times she had to stay under intensive carer in the local hospital as it could be death threats normally. The technology provided during that time only aided her with minimal tasks usually performed by her daughter. Sadly, she passed away in 2013 due to health-related issues but the memories with her will stay with me forever.

References

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