

Invention: Fall Prevention

Initial Situation

From the start, our goal was to prevent falling itself. This meant examining the problem of how and when a fall actually begins. We did not aim to simply recognize a Fall as it is already happening, since at that point it will be too late to countervene. Evaluating walking profiles to monitor fall risk would on the other hand be too laborious since real time movements would have to be constantly fed into existing profiles and there would be a considerable risk of an adverse influence on medication regiments. Instead, we wanted to develop an easily adjustable and workable, light weight system, that is comfortable to wear in everyday life, aesthetically pleasing, of high quality and can be personalized.

State of the Art

Fall recognition has so far been equated with the detection of a beginning or completed fall. For this reason, existing solutions are targeting the event as it happens. One technological solution, for example, is the employment of Assistant Solutions (AAL). They are built into the client's surroundings (e.g. sensors hidden in a carpet floor sensing the fall on impact and maybe the positioning of the body). Another are worn implements that assist the clients movements (bracelets that detect the fall and give an alarm signal, sense and display alerts for heart/cirulatory issues in order to notify the client when such problems arise, exoskeletons that physically support the lower back, mechanically support systems for knees and other joints, orthoses that promote nervous signals, so that desired movements can be fulfilled, inlays for shoes that perceive different kinds of pressure distribution. Most statistical examinations give us only a general sense of when falls happen and how much time there is to react.

Drawback of these Solutions

Either the client is tied to a certain place or the fall is only recognized once it already happened. A continuous, preemptive fall detection is not the current state of technology. Fall prevention is mainly focused on large scale training sessions targeting the nervous system and musculature, sometimes using expensive exoskeletons. This approach is costly, invasive, complex, and full of barriers for the client. Wearing peculiar and bulgy systems in public is humiliating and leads to social stigmatization. The equipment itself has no local system to monitor and prevent falls. The client has to watch out for all acoustic and visual notifications and prevent falls themselves. Mechanical assists only help the fallen client to (maybe) get back up, but only if they are moving in a specific, preconceived direction and angle. Orthoses may facilitate certain medical exercises and therefore prevent permanent disabilities. They are somewhat helpful in everyday walking. The clients feel safer, but falls are not prevented. If the fall is already under way, great forces are needed in specific, time-sensitive vectors. In all described solutions, continuous detection of an imminent fall is not a feature in approach or execution. What kinds of tasks do we need to concern ourselves with to reach our above stated goal?

Task Formulation

At first, we will equate the detection of an imminent fall with an impending volatile condition. Starting from this realization, the following tasks need to be met:

1. To develop a person-dependent mathematical description of a body's biomechanical movement based on the formalized basic movement as an inverse pendulum and possible strategies to prevent the fall.
2. To identify the main functions of movement stabilization and its shortcomings.
3. To deduce interventions and elements that may counteract the impending volatile condition based on these functions.
4. To use these elements as an input for the reaction to prevent the fall.
5. To find an appropriate stabilization strategy for the client.
6. To resolve the stabilization and allow the client to return to a normal, unimpeded mode of movement.
7. To integrate a smart textile, portable data storage, control unit, power source, sensors as detectors, active actors as stabilizers.

Our Solutions

Concerning 1. We created a physical model to support a person's movements and prevent falls through monitoring and – in times of imminent danger of a fall – limited control. The monitoring includes input of influencing parameters on the movement, a constant evaluation in regards to imminent falls and the relaying of these evaluations to the control unit, that in turn uses this information to make decisions on interventions and their detailed parameters.

2. In order to correctly identify the pertaining stabilization strategies, personalized and situational parameters will be used.

3. Past experiences with successful interventions will also be included. These experiences in connection with personalized, technological, and situational data are foundational elements in fall prevention. Further elements can be acknowledged to individualize the system depending on its field of usage, for example include active sports in its purview. All of these elements and data serve as input for the control unit that coordinates the distinct parts of the technological stabilization system.

4. Based on incoming signals, the control unit will deduce what kind of situation is on hand which interventions are ideal to prevent volatility and stabilize the client, or if indeed an intervention is necessary and prudent. This is how certain individual strategies on the client's side, such as flailing of the arms or reaching out to someone, will be recognized and allowed to happen. Furthermore, the control unit will be able to select the best possible strategy out of many, e.g. intervening solely in the lower area of a single leg instead of the whole body.

5. To prevent the fall, the pertinent actors are accessed to counteract any further destabilization. One possibility to realize the actor-system are materials that can be influenced in their flexibility through applying an electric current. Since microhydraulic,

pneumatic, or actors based on piezo-, magneto-, dielectric effects may also be employed, we secured these uses in our patents as well. The fall prevention system is fundamentally variable in regards to which actors will finally be installed. The control unit calculates the actors' target specifications based on the chosen stabilization concept, the situation and the state of the system. The monitoring, coordination, targeting systems, as well as the processing of incoming signals are working together in a cooperative architecture.

6. After the successful prevention, the stabilization will either be resolved, for example by allowing the materials to revert to their previous aggregate state or a part of the stabilization process is kept active. The approach is always oriented towards the aim of returning to mode of movement where the client alone stabilizes their body.

7. The integration of the system into a smart textile is the central intention in its design.

Essential New Value

The presented invention is a complete fall prevention system, from the recognition of an imminent fall in a biomechanically volatile movement situation to the stabilization of the client and the prevention of the impending fall, followed by a reversal of the activated materials. It is entirely wearable, autonomous, easy to handle.

Improved Quality of Life

Elderly people can finally participate in social interactions again. They are able to venture outside, go grocery shopping by themselves, meet with friends without any fear of falling and the connected dread of not being found by someone in due time. Athletes and hobbyists may test themselves in novel situations and gamers enjoy newly developed virtual reality appliances that challenge interactive movements without fear of harm. Its inconspicuous design allows for a free and unashamed employment in public. The market value of this system in Europe alone and focusing exclusively on elderly people with a disposition for falls has to be set in the billions, based on EUROSTAT numbers for deaths, medical emergencies and recovery costs connected to falls. Fewer falls mean fewer instances where home care, physical therapy and surgeries become necessary. The system can be employed to support the clients ability to live an active, engaging, healthy, self-sufficient life.