Biorobotics for Longevity

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P. Dario. Biorobotics for Longevity. Gerontechnology 4(1):1-4. Among the options offered by Gerontechnology, robotics and mechatronic technologies, in combination with advanced biomechanical models, can provide the identification and slowing down of the effects of age-related modifications of the neuro-musculo-skeletal systems. These technologies may increase autonomy of older people by giving them more possibilities of aging at home, and reducing the institutionalization time. A 3-phases approach is proposed: (i) the use of robotic and mechatronic systems to analyse age-related modifications of the motor control strategies in clinics or research laboratories; (ii) the use of wearable systems to assess motor performance in a non-dedicated environment; (iii) the use of technological aids to help elderly to live independently in their domestic environment.

Keywords: biorobotics, biomechanics, aging, rehabilitation robotics, biomechatronics

The population of the world is rapidly aging. The industrialized worlds population structure is showing more than 20% of its citizens aged over 60. In the near future this figure is forecasted to grow up to 25% until 2020 and to more than 30% until 2025[1]. In the same span of time the number of people aged 80 and over will more than double. Japan and the European Union are among the oldest countries. The pyramid of the population of Italy is clearly showing this trend: it first tends to square and later even to reverse within a time period of about a century (Figure 1).

This trend has several social implications, including: (i) a larger number of older people in absolute and relative terms; (ii) an increasing number of frail and disabled people among the older olds; (iii) a smaller number of informal carers (e.g., family carers); and (iv) a smaller size of the productive workforce to contribute to the financing of welfare systems. These effects, in association with the increasing pressure for cost-containment, are posing significant challenges to the health and social care services.

The use of biorobotic and biomechatronic technologies (combined with biomechanical models) can help to identify the effects of age-related modifications of the neural and musculo-skeletal systems, and in some cases even to slow down the changes, thus increasing the quality of life and the ability of the elderly to perform daily life activities. Robotic and mechatronic systems may be used to implement a 3-phases approach: (i) the motor (and cognitive) abilities are assessed in clinics by exploiting the potentials of advanced technologies and systems in order to identify and address major deficits; (ii) when at home, the performance of elderly people is continuously evaluated by using wearable systems to recognize immediately the onset of possible problems related to reduced performance; (iii) technological aids are used to compensate for possible deficits and to increase autonomy, especially at home.

Modifications in the motor control strategies induced by aging processes

In the recent past, it has been proven that older people exhibit in some cases

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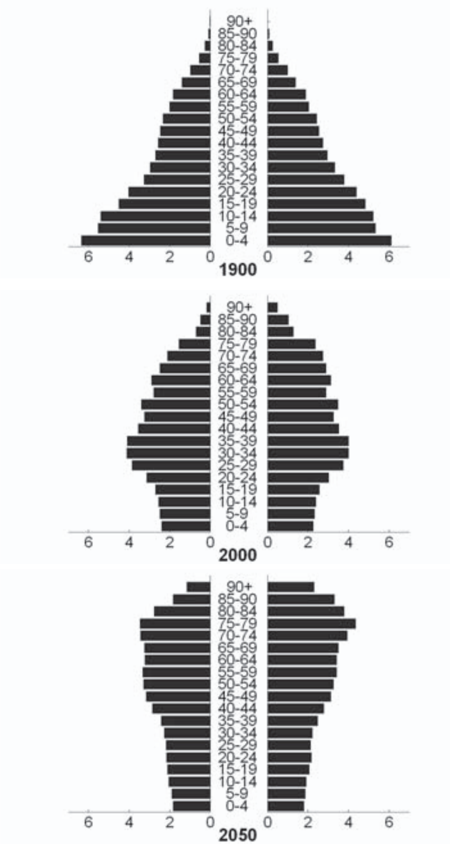

Figure 1. Pyramids of the Italian population (1900-2000) and 2050 forecast[2]

a reduction of their ability to perform different tasks and that this situation can cause severe problems such as an increased risk of falling. Falls represent a high cost for the society, because they often cause fractures which necessarily imply long periods of hospitalization.

Although most research approached the problem of the description of postural responses to unexpected disturbances, a general theory is lacking for the solution of such a problem. A successful method for overcoming such difficulty could be based on the development of biorobotic systems and advanced biomechanical models that could be used as measuring as well as perturbing instruments (Figure 2)[3].

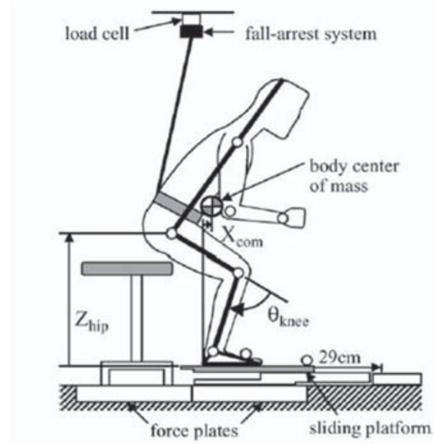

Figure 2. Diagram of the experimental set-up, showing a typical body position of older adults at slip onset. Dashed lines indicate the leg and thigh configuration in the initial seated position[3]*. Z_{hip} is the height of the hip during the movement, X_{com} is the horizontal position of the center of mass of the subject, θ_{knee} is the flexion-extension angle during sit-to-stand. While standing, the foot of the subject is perturbated by a sliding platform*

These biorobotic systems should create quite realistic situations (i.e., inducing slippage or a trip that could be controlled, after an unexpected appearance on the subjects way) but in a controlled environment in order to avoid any damage to the subjects involved in the experiments. At the same time, kinematic and kinetic information must be recorded in order to characterize the response of the subjects.

Real-time assessment of sensory-motor performance in domestic environments

The modifications induced by the aging process can be analysed by using current motion analysis systems, based on passive or active markers placed on the skin of the subjects and tracked by several cameras. Their applicability, however, is limited by cost and is difficult to use in unstructured environments (as home can be). Biorobotic and biomechatronic technologies could develop less intrusive, not expensive, and portable devices which are then donned by the elderly subjects in order to provide real-time information about their sensory-motor conditions, and to anticipate possible problems and damages. The extensive use of microtechnologies to miniaturize the sensing devices can be envisaged (reducing the encumbrance of the wearable system). Wearable systems represent an interesting, and relatively cost saving alternative to the commonly used monitoring instruments in clinical environments. By including light sensing devices and simple data processing systems these systems may easily record continuously important parameters relevant to daily living activities in unstructured environments in a simple way. In the recent past, two wearable instruments, the Human-Glove and the MEKA system have been used to assess hand or knee movements and to evaluate motor performance in elderly people. The MEKA system (Figure 3) measures angular rotations of the knee joint, in two degrees of freedom[4,5].

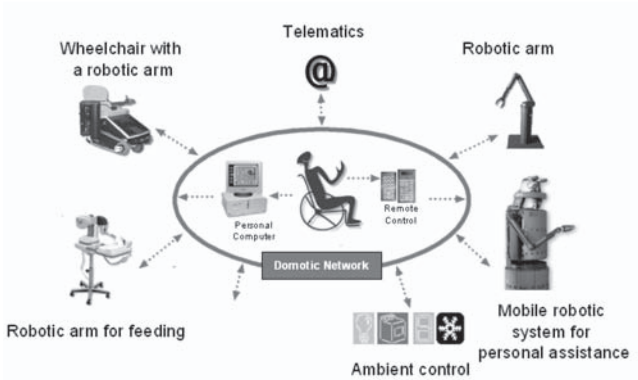

Figure 4. A possible future scenario in the field of robotics and mechatronics for personal assistance[6]

This system[4] is able to provide information on the effects of different cognitive efforts on locomotion and could be used in the near future for the in-house assessment of motor performance especially to try to reduce the risk of falling in elderly people.

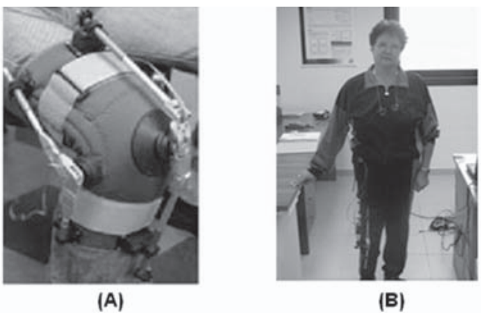

Figure 3. The MEKA system (A) and its use during gait analysis (B)

Technological aids to increase independence and quality of life

The availability of pervasive robotics technology, integrated into intelligent ambients and into global and local networks, will offer acceptable and effective solutions to the growing need for personal assistance, mainly related to the steady increase of the number of elderly people. Personal robots are slowly becoming available that perform tasks such as lifting heavy weights, preparing food, and cleaning kitchen and bathroom, with some degree of customization based on the users motor and cognitive skills, preferences and habits. An example of a future scenario in this field is given in Figure 4.

Conclusions

The increasing elderly population makes it necessary to address several issues concerning the aging effects of the neuro-musculo-skeletal system, and of increasing the level of independence of these persons. In this Editorial, the tools that can be offered by biorobotics in order to address different problems and issues have been briefly illustrated. Although several experiments are still needed to validate the different systems, preliminary findings have shown that they can help elderly to increase their quality of life in a significant way.

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A MESSAGE FROM THE EDITORS

At the start of the 4th volume we want to thank the peer reviewers of volume 3: Sara Czaja, Kees Knipscheer, Jean-Paul Lefèvre, Anne-Sophie Melenhorst, Jan Rietsema, Wendy Rogers, Andrew Sixsmith, Toshiyo Tamura, and Hiroyuki Umemuro, and the members of our editorial board.

In addition we would like to inform the members of the International Society for Gerontechnology and other readers of some of the changes that will take place starting this issue.

To make the information available to the gerontechnological community in a faster way, we have started to place the so-called corrected proofs on the journals website before publishing them in an issue of the journal. Some other improvements include the following. SCRIBUS is now used as the typesetting program. A new website is under construction, making the downloading of individual contributions easier. Best practices are peer-reviewed now, and content pages have been given a different look.

Some minor changes were made in the notice to contributors. Please consult the new rules before sending us your manuscripts.

We are also happy to report that the team of editors has further increased to six, and new representatives from Argentine, Finland, France and the USA have recently strengthened the editorial board.

We wish you an interesting and pleasant reading of the first issue of volume 4!

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