INTESA: An integrated ICT solution for promoting wellbeing in older people

Umberto Barcaro[1], Paolo Barsocchi[1], Antonino Crivello[1], Franca Delmastro[2], Flavio Di Martino[2], Emanuele Distefano[2], Cristina Dolciotti[3], Davide La Rosa[1], Massimo Magrini[1], and Filippo Palumbo[1]

[1] Institute of Information Science and Technologies
National Research Council, Pisa, Italy
{name.surname}@isti.cnr.it
[2] Institute of Informatics and Telematics
National Research Council, Pisa, Italy
{name.surname}@iit.cnr.it
[3] Department of Translational Research of
New Technologies in Medicine and Surgery
University of Pisa, Pisa, Italy

Abstract. As populations become increasingly aged, it is more important than ever to promote "Active Ageing" life styles among older people. Age-related frailty can influence an individual's physiological state making him more vulnerable and prone to dependency or reduced life expectancy. These health issues contribute to an increased demand for medical and social care, thus economic costs. In this context, the INTESA project aims at developing a holistic solution for older adults, able to prolong their functional and cognitive capacity by empowering, stimulating, and unobtrusively monitoring the daily activities according to well-defined "Active Ageing" life-style protocols.

Keywords: Ambient Assisted Living, Long-term monitoring, Well-being assessment

1 Introduction: the INTESA project

With a continuously increasing percentage of the older population, interventions to preserve health and tools to assist people are urgently needed. Such needs require to identify older people at greatest risk of adverse health events: frail older adults are the major and the most vulnerable subset [1]. Many older people experience age-related losses in different domains of functioning (i.e., loss of mobility, vision, cognitive abilities, or social contacts) that lead to a complex mixture of problems. Mobility issues and losses in the user's social network can result in social isolation; furthermore, several chronic conditions can cause low physical fitness and a depressed mood. Such issues increase the risk of adverse outcomes, such as unsuccessful aging, inadequate use of health care, hospitalization, institutionalization, death, decrease in social activities, dependence on others, caregiver burden, lower levels of well-being, and adverse health outcomes [2].

In this context, the INTESA project is devoted to provide a suite of customizable and highly innovative services to improve the lives and the well-being of elderly and, in general, sedentary or frail people living in their own homes, who suffer of illness or several grades of disabilities and are difficult to reach. The suite of services presented in this work is developed using modular programming techniques in order to easily allow further development of tools, algorithms and services. Furthermore, each module is developed using the best state-of-the-art of e-health, e-inclusion, wireless sensors networks and artificial intelligence applied to data mining. The target users of INTESA will pro-actively and consciously benefit of several services, both in outdoor and indoor environments.

These services deal with most of the user's daily life, in many ways:

- promoting physical and cognitive activity both in the domestic environment, using exer-games, and in outdoor scenario, using specific training schedules. These goals will be reached using wearable devices able to detect physical activity and to provide customized tools to support and verify their fitness training;
- unobtrusively monitoring the user's sleep quality;
- monitoring of changes in weight and level of motor skills and balance. The latter is particularly important in order to prevent falls;
- monitoring the protein-calorie consumption and dietary habits;
- monitoring social interactions through personal mobile devices and the collection of context information characterising the situation the subject is experiencing (e.g, indoor localization, daily activities organization);
- defining a behavioral pattern model, fusing together short-term monitoring information in order to detect changes in the user's daily routines possibly related to physical and/or cognitive decline, stress conditions and mood.

The rest of this paper is organized as follows: Section 2 describes the existing related initiatives, both in the Italian and European domain, highlighting strengths and weaknesses of the existing approach and how INTESA addresses them; Section 3 presents the core services provided by INTESA and related works in their fields, Section 4 describes the parameters identified to assess the well-being of the user and the long-term evaluation plan. Conclusions are drawn in Section 5.

2 Related initiatives

The last decade have seen an increasing interest in Health&Well-being research, both from the research communities and from governments. In September 2011 [4], the European Commission has published an interesting book, titled "e-Health Projects. Research and Innovation in the field of ICT for Health and Well-Being: an overview", containing a collection of European projects focused on various

[4] http://ec.europa.eu/digital-agenda/en/news/ehealth-projects-research-and-innovation-field-ict-health-and-wellbeing-overview

approaches on this research field. Furthermore, the European research program H2020 Societal Challenge 1 (Health, demographic change and wellbeing) contains many calls for the study and development of ICT for Health technologies, with the clear objective of promoting an easing technology transfer to the people, especially elderly. Consequently, nowadays it is common to denote this trend using the "Active and Healthy Aging" label and, in this field, the European commission has set the goal to reach increasing life expectancy and to allow a more independent life for older adults.

Into the European community, the Swedish Institute of Assistive Technology (SIAT), successively Institute for Participation, has offered significant works in the field, with a focus on remote health care facilities development, especially for people in a fragile state, due to an illness or health problems [5]. Furthermore, their fruitful collaboration with industrial partners (i.e. RobotDalen) has provided many technologies, tools, and instruments to the world wide community, allowing prevention of illness, cognitive and mental health issues and, in general, assisted living solutions based upon the conviction that also the people who are facing health issues can lead their life with an overall high quality, both into their own house and in social environments.

From the industry point of view, this ambition has seen an extended participation of the largest high-tech companies. For example, Microsoft and IBM have recently spent a big effort on this field offering many solutions for fragile people. In particular, IBM with the collaboration of Bolzano municipality, has developed the "Abitare Sicuri" project [6], which is able to enable the remote health paradigm. Indeed, residents of this Italian community can benefit from using remote communication with hospitals and clinicians, monitoring their own progresses in the rehabilitation phases. On the other hand, the remote monitoring allows proactive health-care practices and residents can benefit from context-aware solutions, providing early clinical deterioration identification and behavioral patterns detection. Finally, these information are used to provide alerts and notifications to the hospital, expert medical or social services staff, using SMS, e-mail, and online social networks. Partners of this project claims a collection of more than 238000 environmental data and 541 different alerts. These alerts have produced a professional staff's intervention in about the 25% of cases.

Along the guidelines set by the European community, each country has developed its own health-care innovation plan. In Italy, several national project calls are focused on Smart Cities and Communities, aiming at finding people needs and promoting tools for their well-being. In particular, in [7], an interesting work, namely "Italia Longeva", is proposed involving many public organizations (Ministry of Health, Region of Marche, Inrca Institute of Ancona). It manages the health-care challenge from a technical and clinical point-of-view more than the well-being perspective but, at the same time, it represents a good starting point for creating solutions able to connect together several and different technologies

[5] http://www.mfd.se/other-languages/english/assistive-technology-in-sweden/
[6] https://www-935.ibm.com/industries/it/it/bolzanocity/
[7] http://www.italialongeva.it/

and paradigms, from monitoring of blood glucose to home automation software able to check the contents of the fridge. Another notable project in this field is represented by "Safe home" [8]. It is developed by the Region of Veneto, through "Associazione Temporanea D'impresa" and relies on advanced home automation system development, with a focus on tele-medicine and home-care making possible the integration among hospitals and community services in the provision of care for patients affected by various diseases. It is based on a medical device that is easy to use, thanks to touch-screen technologies and an accurate user experience interface, and provides information via a privacy-aware cloud infrastructure. Different projects focus on specific technologies enabling the provisioning of remote health monitoring. In this field, the AMICA project [9], involving several institutes (Istituto Superiore Mario Boella, Università dell'Insubria, and other private companies), shows an interesting smart-watch, able to detect: i) people falls by employing tri-axial accelerometers and ii) strong sedentariness conditions by analyzing micro fingers movements. The project relies on the use of smartphones and it exploits the Zigbee technology for the data transmission purpose.

Finally, it is worth noticing how these projects and outcomes are centered on a very particular category of people or situation. The lack of a holistic solution that can provide more general services, customizable by users using several physiological, cognitive, psychology aspects, poses a big challenge in this research field. We deal with this challenge proposing the INTESA system, a modular framework able to provide several services related to the e-health, well-being, and social inclusion. Furthermore, it is highly customizable and expandable, providing services to various category of end-users. This aspect represents its key feature.

The INTESA system is still under development, but it already contains different algorithms and modules able to collect and process sensors data gathered from several different sources of information. In particular, INTESA contains modules for sleep quality monitoring, fitness and calorie consumption tracker, indoor positioning, posturography and stabilometry monitoring, and it provides tips, suggestions and exercises to the end users in order to improve their own health status and social activity. These modules allow to perform both short-term and long-term monitoring on which to base the development of techniques for behavioral pattern identification, allowing the identification of early signs of clinical deterioration in fragile people.

It is worth noticing that each module above mentioned represents a research challenge itself. In the following section we will introduce the specific issues addressed by each module and the implemented techniques.

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[8] http://www.consorzioarsenal.it/web/guest/progetti/safehome/il-progetto
[9] http://www.adamo-vita.it/

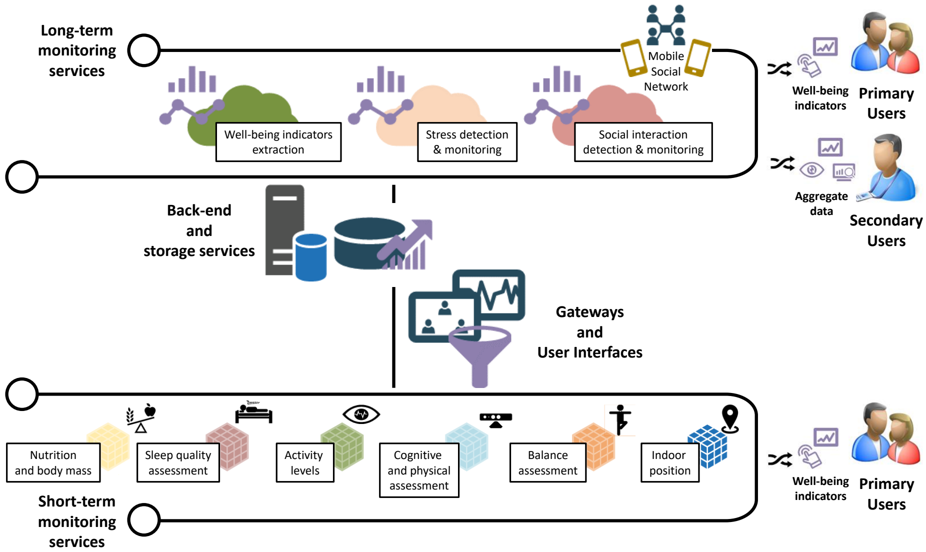

Fig. 1. The INTESA overall architecture

3 Core services

From the architectural point of view, the overall INTESA system is composed of different software artifacts that are independent of each other. These modules are deployed on different hardware and send the gathered data to a single central unit able to perform the monitoring, detection, and signal processing tasks. In this way, the system is robust to malfunctioning of a single device and it is ready to develop further modules.

Figure 1 shows the overall architecture of the system, together with the distinction between primary and secondary user. The term primary user refers to the older adult who interacts with the system. The primary user is in direct contact with the devices and directly benefits from the INTESA lifestyle protocol. The secondary user represents the social networks around the primary user, from caregivers and medical staff to relatives, that benefits from the INTESA indicators to better intervene in helping the primary user to follow the active ageing lifestyle protocol.

The overall INTESA architecture is composed by three major elements:

- **Short-term monitoring subsystems.** These modules provide indicators about the physical and cognitive status of the user, related to the activities performed during the daily living. In this subset we find: the nutrition and body mass monitoring module; the sleep quality assessment module; the activity detection module; the cognitive and physical exercises monitoring module; the balance assessment module; the indoor position monitoring module.

- **Long-term monitoring subsystems.** These modules provide indicators about the physical, cognitive, and social status of the user, related to the overall period of intervention of the INTESA lifestyle well-being protocol. In this subset we find: the well-being indicators extraction module; the stress detection and monitoring module; the social interaction and monitoring module by means of a mobile social network.
- **Back-end services, gateways and User Interfaces.** These modules represent the software infrastructure that provides to the different subsystems the capabilities to: collect and store data; run the business logic to infer the different well-being indicators; provide feedback to primary and secondary users.

In the following sections, we will describe in details the algorithms and technologies used for each module.

3.1 Nutrition and Body Mass

This service aims to monitor and evaluate the temporal evolution of very common pathological conditions in elderly people such as sarcopenia (muscle mass loss/reduction), osteopenia (bone mass loss/reduction), dehydration and excessive visceral fat percentage. The service is based on the use of a bioimpedance scale to collect physiological parameters (e.g., hydration level, body mass index, weight, etc.), and on a mobile application to record dietary habits of the user, based on a personalised diet program.

The service's output represents a valid support and integration for clinical evaluations by medical staff to control these important pathological conditions concerning fragile subjects. In fact, dehydration and sarcopenia are considered risk factors for postural instability, falls, fractures and even cognitive decay (which can degenerate in Alzheimer disease), and they can often represent malnutrition indices. Several recent works in literature point out that malnutrition is one of the most relevant conditions that negatively affects the health of elderly people, both in home-based living and assisted living facilities. In almost all the studies the nutritional status of the subjects is evaluated using the Mini Nutritional Assessment (MNA) or its short form (MNA-SF) as nutritional screening tools. One of the most extensive studies presented in [3], which included more than 4,500 elderly subjects of 12 countries in 4 different settings (hospitals, nursing homes, rehabilitation facilities and communities), showed that approximately two-thirds of study participants were at nutritional risk or malnourished, with different rates among the settings. For this reason, we decided to integrate the physiological monitoring service with a nutritional monitoring service, based on the user profile and the dietary options provided by the local structure. In addition, we integrate the results of the two services with the information related to the daily calories balance provided by INTESA wristband. As far as the nutritional monitoring service is concerned, we developed a mobile app for Android tablet and smartphones, and a back-end server to safely store and analyze the collected data. The service has two versions: one designed for autonomous subjects, living at home and able to cook and follow personalized suggestions; the other one is designed for care givers, aimed at managing several subjects in a residential nursing home. The second version of the app is used in INTESA to provide an additional service both to the medical partner, by increasing the monitoring data, and the local structure, to improve the management of the canteen service.

3.2 Sleep quality assessment

One of the most important markers of a healthy lifestyle is represented by the quality and quantity of sleep. These factors directly affect the waking life, including productivity, emotional balance, creativity, physical vitality, and the general personal health. Indeed, poor long-term sleep patterns can lead to a wide range of health-related problems, such as high-blood pressure, high stress, anxiety, diabetes, and depression [4]. In this context, the monitoring of sleep patterns becomes of major importance for various reasons, such as the detection and treatment of sleep disorders, the assessment of the effect of different medical conditions or medications on the sleep quality, and the assessment of mortality risks associated with sleeping patterns in older adults [5].

Several studies have dealt with the sleep monitoring research challenge [6]. In [7], authors show an actigraphy-based system in order to provide users' feature along a sleep session. In [8], a breathing detection system is presented, while, in [9], authors show an innovative electrocardiography-based approach. The main drawback of these methods is that an obtrusive system is required.

The sleep quality assessment module of INTESA is able to provide sleep features in an unobtrusive way, using a small amount of Force Sensor Resistors (FSRs) and inertial transducers. A similar approach is shown in [10] but, in their work, authors reach the same goal using several expensive transducers, increasing the cost and maintenance of the system. Further details, together with the dataset used for testing the system in the laboratory, can be found in [11].

3.3 Indoor localization and activity detection

Activity detection and tracking is a research field that has seen an increasing interest from the ubiquitous and context-aware computing research community, which have a considerable impact on the medical settings and protocols [12].

Considering activity tracking systems, it is possible to distinguish two different approaches: based on wearable devices and device-free. Nowadays, several wearable devices have been presented in the market, equipped with several and different technologies and sensors, such as accelerometers as well as biological parameters transducers. The main drawbacks of this kind of approach is related to the user experience and comfort. In literature, the need of semi or completely unobtrusive solutions has been managed using videocameras [13], although this approach leads to issues from the end user perspective. Indeed, privacy aspects and the feeling of being watched are the key concerns involved with this approach. Besides, these solutions present some technical hurdles, mainly due to low resolution, poor light condition, fields-blind especially into indoor environments and a general computational complexity demand which is a big issue in real-time scenarios. The INTESA system manages these issues taking advantage from the availability of innovative solutions, such as wristbands equipped with several sensors, allowing a high-quality user experience through a discrete and low intrusive approach.

Another key module of the INTESA project is the indoor positioning and localization. This challenge is one of the main goals of context-aware systems [14–16], in particular in the Active and Assisted Living (AAL) scenarios [17]. Indeed, thanks to an accurate indoor positioning detection, it is possible to infer more complex activity. It is well known that outdoor localization is well performed through Global Positioning System (GPS) technology. In general, GPS is not available to indoor positioning scenarios, due to the fact that the signal received from the satellites is not strong enough to reach indoor places through the walls. In literature, several works have been presented in order to reach the ambitious goal of having a stable indoor standard de-facto as the GPS solution, but it still an open issue [18, 19] with a trade-off between performance and costs. Furthermore, in indoor scenarios, like hospitals and nursing homes, some hardware and technologies deployment may not be allowed. This is the case of the INTESA project, posing a big challenge on the proposed solution that has to be unobtrusive and hidden to the final users, easily configurable, and reliable. The state-of-the-art of the indoor localization system is mainly represented by range-based system. In detail, these system works using radio characteristics, such as: received signal strength intensity (RSSI), time of arrival (TOA), angle of arrival (AOA) and time difference of arrival (TDOA). All these features can be extracted knowing the exact position of the station and anchors involved into the communication protocol. Consequently, they required ad-hoc and accurate hardware deployment. Considering the reference AAL scenario, our system has to deal with low cost and unobtrusive constraints. For this purpose, INTESA has performed an in-deep literature review of real-time indoor localization systems (RTLS), analyzing strengths and weaknesses of each available method, and choosing as reference technology and communication protocol the IEEE 802.15.4a standard for its high performance and low obtrusiveness with lowering costs in the recent years.

3.4 Cognitive and physical exercises

The hardware of the implemented system consists of: a motion-sensing device, an electroencephalographic (EEG) headset, and a personal computer connected to the integrated database of the INTESA project. As regards the motion-sensing device, we have used the Microsoft "Kinect V2" infrared-based sensor to characterize human gestures and movements. As regards the EEG headset, we have used the Interaxon "Muse" portable system for the acquisition of four EEG traces (Fp1, Fp2, TP9 e TP10) at the sampling frequency of 256 Hz by means of dry electrodes. The electrode mounting is quick and easy because the device is wireless and simply wearable.

The software applications allow the motor and cognitive activities to be executed and the required measures to be performed. These activities are divided into two categories: exercises, aiming to improve the condition of the subjects, and tests, aiming to measure this condition. However, exercises are actually accompanied by measures, and tests can have a positive effect on the subjects. During the execution of the exercises the movements are constantly monitored by Kinect.

The exercises so far proposed are: mimic the movement of an avatar projected on the screen; connect the dots; select the tile. The avatar movements present different degrees of complexity; they include movements of the upper part of the body (e.g. raising arms) and related to lower one (e.g. get up and sit on a chair). Mimicking the movements is primarily a motor exercise, which however requires cognitive abilities (with useful effects reported in literature [20], both in understanding what the avatar is doing and in performing a correct imitation. The classic connect-the-dots task also presents various difficulty levels, according to the number of involved dots and to the required speediness. The select-the-tile task is an exercise which involves both cognitive and motor tasks, consisting in selecting the image that conceptually corresponds to a sound generated by the system (for instance, a car passing in the street, a bird singing etc.). These exercises are not only beneficial, but also somehow playful, and performing them is generally pleasant. The software applications for exercise administration are characterized by flexibility, allowing different movements, different images, and different sounds to be appropriately created and combined. The tools for the evaluation of the performances include: identification of the correctness of single responses (e.g., correct vs. incorrect tile), measure of the reaction times (exploiting the effective time-measure precision of Kinect), and measure of movement precision (in the movement-mimicking task, by comparing the avatar movements with those of the subject, which are measured by Kinect).

An application for administering a simplified version of the classic ANT test for the measure of the attention level has been implemented. This test consists of six patterns (a central arrow pointing at right / left with neutral / congruent / opposite direction of the flankers); each pattern is visualized on the screen with a visual angle of 3.8 degrees for 2 seconds with a 4-second interval. The subject is asked to lift the right / left arm according to the direction of the central arrow. The effectiveness of this test [21] is due to the fact that it can measure the condition of the three brain network systems that are respectively responsible for the functions of alerting (i.e., reaching and maintaining an alert state), orienting (i.e., selecting sensorial information), and performing executive control (i.e., solving conflicts among different possible responses). The applications for the analysis of the data provided by Kinect measure the response correctness (right vs. left hand) and the reaction times. Applications have also been implemented for the analysis of the EEG traces acquired by the Muse headset. A preliminary tool allows the epochs containing artifacts (which are mostly due to blinking) to be recognized. This is achieved by applying thresholds to both the signal amplitude and the derivative amplitude. A second application provides the average power of arbitrary EEG band activities over artifact-free intervals. So far, in the light of relevant literature [22], the following bands have been studied: lower alpha (7-10 Hz), higher alpha (10-12 Hz), lower beta (12-18 Hz), and upper beta (18-26 Hz). The results offered by the application of this tool to different intervals can be used to calculate three kinds of average powers respectively during, before, and after pattern visualization during the ANT test. A further tool provides elementary statistical methods (such as binomial test, t-test, Wilcoxon test, linear correlation) for comparisons between data sets (e.g., among EEG band powers averaged over different intervals). These tests can be applied to various kinds of comparison: among different experimental conditions in the same session; among different sessions for the same subject, to see if his/her condition has improved; among different subjects; and among experimental heterogeneous data, such as EEG signal and reaction times.

3.5 Balance assessment

The objective of this module is the development of a learning system for the automatic assessment of balance abilities in elderly people. The system is based on estimating the Berg Balance Scale (BBS) [23] score from the stream of sensor data gathered by a Wii Balance Board. The scientific challenge tackled by our investigation is to assess the feasibility of exploiting the richness of the temporal signals gathered by the balance board for inferring a balance assessment index derived from the BBS score based on data from a single BBS exercise.

In previous work [24], the relation between the data collected by the balance board and the BBS score has been inferred by neural networks for temporal data, modeled in particular as Echo State Networks within the Reservoir Computing (RC) paradigm [25], as a result of a comprehensive comparison among different learning models. The system resulted to be able to estimate the complete BBS score directly from temporal data on exercise nr. 10 of the BBS test, with 10 s of duration. In the INTESA project, we exploit the results obtained by the neural network approach to build up an unsupervised model able to detect macro-categories of balance in the target user. Overall, the proposed module puts forward as an effective tool for an accurate automated assessment of balance abilities in the elderly and it is characterized by being unobtrusive, easy to use and suitable for autonomous usage.

3.6 Stressors detection

The term stressors refers to stimuli of different nature that carry the human body and mind to reach high stress levels. Such stimuli can be physical, environmental, social, cultural, psychological, affective and even nutritional. Stressors can be distinguished in benefits and harmful. The former ones act as challenges and generate the so-called positive stress or eustress, while the latter ones generate the so-called negative stress or distress, which can lower the immune defenses and lead to first problems such as anxiety and insomnia. This status can also be followed by long-term disorders and diseases. This service exploits wearable devices focused on the detection of physiological parameters able to reflect the autonomic nervous systems functionalities (both sympathetic and parasympathetic branches). Such parameters include Heart Rate, Hearte Rate Variability, blood pressure, respiration rate, body temperature and Galvanic Skin Response (GSR). The hardware of the implemented system consists of: a wrist unit with finger electrodes for GSR monitoring, a chest strap for cardiorespiratory monitoring and a mobile personal device (smartphone/tablet) which acts as a gateway for collecting sensor data on standard Bluetooth or Bluetooth Low Energy communication channel. As far as the GSR sensor is concerned, we have used Shimmer3 GSR+ Development Kit [10], while the cardiorespiratory monitoring is performed by using Zephyr Bioharness3 [11]. Both the wearable devices included in the system are equipped with IMU sensors, like 3D accelerometer and gyroscope, to collect physical activity and posture data.

Stressors detection and analysis in elderly people can enriches the monitoring of subjects while executing daily activities, such as physical rehabilitation exercises performed at the gym supervised by physiotherapists, guided cognitive tasks and recreational and social activities. In addition, they represent an important source of information in case of depression. In the current clinical practice, psychiatric diagnosis is carried out through questionnaires and scores scales (e.g. Beck Depression Inventory), ignoring the potential contribution provided by physiological signals. This service is aimed also at investigating how some changes in the nervous system activity can be correlated with clinically measurable *mood* transitions.

3.7 Social interactions

Maintaining an active social life is very important in elderly to prevent depression and cognitive decline. For this reason, INTESA integrates a social monitoring tool in the services suite. It is based on the use of personal mobile devices, able to exchange data through device-to-device communications (based on BT-LE and/or WiFi Direct standards) and to collect context information characterizing the situation the subject is experiencing. In this way, the application can be used both in controlled environments (like nursing homes) and independently. In the first case, the application leverages also on contextual information derived from the daily activity organization and by the indoor localization system. In the second case, the environment is more dynamic, and the application is able to monitor also social interactions outside the home environment, both exploiting GPS sensing and by stimulating external subjects to use the same application. In fact, the application is completely unobtrusive, it does not require any interaction with the user and it is optimized for resource-constrained devices.

[10] www.shimmersensing.com
[11] www.zephyranywhere.com

4 Well-being assessment and long-term evaluation

The services discussed above compose the key modules of the INTESA project. The main goal of INTESA is to build Upon these modules a suite of high-level services that give to the primary and secondary users aggregate indexes of the overall well-being status of the user.

Several works have tried to realize efficient people activity detection, with a high-level of information [26]. INTESA promises to finally realize the "smart home" paradigm [27]. Data gathered and managed by different modules can be analyzed using different time windows. In this way, many behavioral characteristics and features can be extracted and inferred. Moreover, drift phenomena from usual behavioral patterns can be early detected [28–32]. Models of behavioral patterns can be found through different approaches. In literature, many works present a probabilistic approach, discriminant function analysis and clustering-based [33]. These approaches can be summarized in two categories: data-driven and model-driven. Basically, they depends on a priori knowledge availability [34].

In the INTESA scenario, we will manage several time-series, gathered from different technologies. Consequently, the INTESA approach fall into the data-driven category. As shown in [35], this methodology allow a more realistic behavioral model as outcome. In general, data-driven techniques arise from: supervised learning tools (especially from probabilistic classification) [36, 37], data-mining [38, 39], and inductive learning [40, 41]. The main drawback of supervised approaches is represented by the ground-truth construction, a process in which the end user is involved. With the purpose of minimizing the effort required from the users during the ground truth collection, INTESA is focused on semi supervised or unsupervised learning approaches, particularly used for hidden pattern recognition and motif discovery [42]. Preliminary results have been obtained on different real cases datasets, built in previous related EU and national projects in the field [43–45]. Further details on the techniques used by the long-term monitoring modules can be found in [46, 47].

From the long-term evaluation perspective, INTESA will test its services in a six months trial involving 15 users to be enrolled among the residents of a nursing home co-operating with the project. To the purpose of validation, the study will divide the participants in two sets: the set of users that received the INTESA protocol (intervention group, 10 users) and the set of users that did not receive it (control group, 5 users). The comparison between the improvements achieved by these two sets of users during the pilots was expected to give an indication of the validity of the overall INTESA life-style protocol.

5 Conclusion

The INTESA system is designed to be useful to patient (primary users), clinicians, nurses, and caregivers (secondary users) through several remote monitoring services, improving the coordination among hospitals and community centers. This generates many other benefits, since INTESA helps reducing avoidable readmissions, offering more cost-effective solutions in treating the chronically ill patients, and identifying early signs of clinical deterioration in patients. It can also draws new industrial investment, promoting ICT market opportunities. From a technological point of view, INTESA is composed of different modular services covering the main dimensions of the daily living of the users, from monitoring nutrition, indoor activity, and sleep quality to suggesting an "Active Ageing" life-style protocol to the user. The modules are based on beyond the state of the art techniques and infer useful indicators of the physical, social, and cognitive status of the user. From the long-term evaluation perspective, INTESA is planned to be tested in a six months trial involving 15 users divided in two sets, intervention and control groups, in order to validate the proposed approach.

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