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ACANTO

A CyberphysicAl social NeTwOrk using robot friends

Deliverable 1.6

User requirements

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Authors: Andrew McNeill (UNAN), Lynne Coventry (UNAN), Ignacio Peinado (SERMAS), Cristina Sandoval (Envitel), Maria Julia Silla (Envitel)	
Internal reviewer: Luigi Palopoli	

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Executive Summary

The following deliverable (D1.6) provides the initial user requirements for the ACANTO system. The aim of the ACANTO project is to provide 3 system components to support the creation of a social network to support maintaining and increasing social groups; monitoring activities and making recommendations for future activities that maintain mobility and inclusion; provide a user-friendly/persuasive interface to network/walker and recommendations; create an activity program for delivery via a walker for rehabilitation activities and monitor progress.

After describing the system, the relevant user groups are identified and scenarios of use (use cases) are provided. After the scenarios, the high-level user requirements derived from the use-cases are provided in a table. The requirements focus on the Activity planner and recommender systems, the CPSN (Data-gathering and networking abilities), the FriTab (Data gathering, UI, Information communicated to user, and presence of user profiles) and the FriWalk (availability, data gathering, guidance abilities, information presented to users, physical form and exercise recommendations).

In this revised version of the deliverable, use cases have been more clearly linked to requirements by specifying the IDs of the requirements that emerged from specific use cases. Furthermore, stakeholder involvement has been clarified by including details of the clinical workshop in Madrid where many of the clinical requirements were identified. This has been fully elaborated in notes from the meeting provided in Appendix 1.

1.1. Introduction

The following document provides the initial user requirements for the ACANTO system. These requirements were derived from a set of user scenarios. These scenarios were created from information gained from a number of sources; our previous work with older adults in the Dali project; working with clinicians at Getafe Hospital; interviews with older adults as part of the barriers and motivators task (D1.2) and interviews with older adults after they had experienced the first prototype. After describing the overall system, the relevant user groups are identified and our sources of information presented. The scenarios of use (use cases) are then summarised. After the scenarios, the high-level user requirements derived from these are provided in a table. The requirements focus on the CPSN (Data-gathering, networking abilities, activity planning, and recommender system), FriTab (Data gathering, GUI design, Information communicated to user, and presence of user profiles) and the FriWalk (availability, data gathering, guidance abilities, information presented to users, physical form and exercise recommendations).

1.2. System description

The ACANTO system comprises three main parts: the FriWalk, the FriTab and the Cyber-Physical Social Network (CPSN). The FriWalk is a robotic-friend that is able to guide users through an internal physical environment, avoid obstacles and encourage physical activity. This system will also sense the user's emotional state and habits to provide customised feedback. The FriWalk will come in two forms: the rehabilitation FriWalk and the generic FriWalk. The former will have additional gait and balance-detection technology, which will not be included in the generic FriWalk. The FriWalk will link to the FriTab which will contain a recommendation system to suggest activities as well as providing the interface for the cyber-physical social network. The system is intended to work coherently so references to "the system" refer to the entire tripartite product.

1.1. General Requirements from the project Team

Overarching requirements were agreed on by all the project team through discussion of key issues and based on an understanding of what can be achieved with current technology and the cost of the product. Key issues regarding the FriWalk and FriTab are summarised here.

The FriWalk

It was agreed that the FriWalk would not be owned by individual users but would be owned by institutions such as hospitals (in the case of the rehabilitation walker) and museums (in the case of the generic walker). In this case, the device will be operated by multiple users who have separate user profiles. Because the FriWalk will be the possession of institutions rather than individuals, it will not be designed for use in a home-environment. It will be used indoors in hospital environments (for rehabilitation) and museums or shops (for the generic walker).

FriWalk functionality

It was agreed that the FriWalk will provide exercise recommendations to users. Performance on these exercises will be monitored and presented to the user and medical professionals. The FriWalk will have navigation functionality and obstacle-avoidance capability. In the generic version, the long-term planner will navigate the user to a specific destination whereas in the rehabilitation version, this will not be as important. The rehabilitation version will continuously monitor walking features to detect improvement or decline and will then send relevant information to health professionals. Such professionals will also be able to set targets for users with respect to speed, gait and posture.

FriTab interface

The interface for both versions of the FriWalk will be the FriTab, which will provide a visual interface for users. Any FriTab can be used to sync with the FriWalk. Haptic feedback can also be provided for some features.

1.3. Understanding stakeholders

Given the technical framework outlined in section 1.3, we also gathered information from stakeholders.

There will be several stakeholder groups with different interests in the system and with different needs:

1. **Older adults** will be interested in the system to provide physical assistance, navigational assistance and the facilitation of social interactions. These older adults will be potentially frail but do not require full-time assistance. They will want the system to provide physical assistance, provide help in navigating the environment and provide opportunities to engage in social activities with others who have similar interests.
2. **Younger adults** will be interested in the device to provide social activities to enable interaction with an older generation who can provide mentoring and knowledge.
3. **Non-clinical carers** of older adults may want to use the system to provide geolocation information for those under their care. They may also wish to monitor the activities of the users and communicate with the older adult users.
4. **GPs** will be interested in the system to provide data on the physical activity of their patients along with any data that might indicate a decline in balance, strength or stamina.
5. **Rehabilitation clinics** will be interested in gaining data from the system about their patients' gait, balance, strength, stamina, and adherence to their exercise regime.
6. **Rehabilitation patients** who have suffered falls and are in recovery will want to use the device to provide assurance of physical support with information on their improvements in balance, strength, stamina and gait.
7. **Community groups, libraries and museums** (along with similar organisations) will be interested in using the system to provide information about upcoming events and activities and to gauge interest in future events and encourage more older visitors.

In the first iteration of the requirements gathering we focused on older adults, rehabilitation clinics and rehabilitation patients.

1.4. Sources of Information for User Scenarios

To support our understanding of older adults who are not currently in need of the rehabilitation aspects of the system, we utilised the information gathered in the motivation and barriers work, described in deliverable 1.3. This provided us with information about what people want to do, with whom, and what barriers prevent them from doing so. This information was gathered from a total of 18 participants. Ten of them were interviewed in Italy (6 females, 4 males; age ranging from 65 to 102 years old, mean 75; 5 from rural areas, 5 from urban areas), and 8 in the UK (4 females, 4 males; age ranging from 60 to 87, mean 70, 8 from urban areas). This information allowed us to create realistic scenarios of what people wanted to do and to explore how the system would support that desire.

Rehabilitation scenarios were generated from research conducted at Hospital Universitario de Getafe by staff who work extensively with older adults, and researchers from Envitel who conducted interviews with staff and patients at the hospital. These requirements were derived from information gathered via a workshop at the hospital with all project members and 6 members of the rehablitation team at Getafe. This included the Head of the Service, a geriatrician and the occupational therapist of the Day Hospital. We also observed a patient going through the different exercises, to allow us to see what problems they experienced during the rehabilitation tasks. This allowed the team to consider how the system could support such users. During this time we discussed with the clinicians what support they would like to see from the walker, and what would be seen as a significant improvement to what they could do today. (See Appendix 1).

Initial discussions about the requirements at Getafe have involved the Director of Geriatrics Services, the Head of Falls and Fracture Unit, an occupational therapist, 4 orthogeriatricians and 3 residents. These discussions about have resulted in refinements to the scenarios. Between January and February 2016, 6 older adults in different conditions were interviewed at Getafe and used a prototype of the walker interface. The results from these interviews were used to refine the clinical scenarios and the requirements, as well as to develop a new version of the UI of the FriTab, that will be validated within the scope of Task 1.3.3.

The information from this work has served as input to the generation of use case scenarios. These scenarios express, from the perspective of the user, what has to be achieved by the system.

1.5. Use case scenarios

Using the user groups identified, scenarios of use were generated to show how each type of user would use the system and its components. The scenarios outline characteristics of the user and

highlight the need for specific functionality and these are identified in the table of requirements following the scenarios. The advantage of scenarios is that they can be used to discuss the system with stakeholders to predict acceptance as well as being used to highlight specific requirements. Here they are used to highlight specific requirements. In later studies, they will be discussed with potential users in discussion groups to indicate acceptance of the technology and why.

Each scenario is divided into several sections: *Demographics* (to describe the type of user), *Location* (to identify whether the user is rural or urban), *Lifestyle* (to indicate current levels of activity), *Gap for activity* (to highlight where the system could be used within the user's life), *Desire for activity* (to highlight potential desire for the system's functionality), *arrival of system* (to explain how the system arrives with the user), *recommendation* (the type of recommendation provided by the CPSN recommender system), *basis for recommendation* (how the system knows what to recommend), *decision* (how the user responds to the recommendation), *implementation* (how the system assists in performing the recommendation), *using FriWalk features* (how the FriWalk contributes to the experience), and *result* (what happens after the recommendation has been followed). Not every section is relevant for each use case.

In the right-hand column, the requirements identified from the scenario are noted by giving the accompanying ID from the user requirements table below. Not all requirements are listed beside every scenario to avoid duplication. Several requirements are not listed because they are general requirements and do not link to specific scenarios. Requirement 34 relates to general ethics of the system (right to withdraw), requirements 50 and 51 are general requirements for good user-interface design for the FriTab, and requirements 62-65 and 68 are general FriWalk requirements dealing with the need for a usable walker.

Use case 1: Older user using FriTab

Section	*Narrative*	*Requirement ID*
Demographics	Anthony is a 75-year-old man who lives alone.	
Location	He lives in sheltered housing near Gateshead town centre.	
Lifestyle	He lives a quiet life and doesn't get out much. Two or three times a week he walks to the local superstore to buy groceries.	
Gap for activity	Anthony used to work as a miner and would meet with his friends every week for a meal. Many of his friends have since passed away or no longer live in the area.	
Desire for activity	He wishes he could meet up with friends to spend time together.	
Arrival of system	One day he receives a FriTab from the manager of his sheltered housing community. After spending five minutes telling the system about his interests, background, and some people that he knows, the system now begins to link him with other people who have similar interests and backgrounds.	16, 29, 30
Recommendation	The next day, the system recommends that Anthony meet up with a man named John who, according to the FriTab, used to work in the coal mining industry.	5
Basis for recommendation	The FriTab thinks that because both men worked in the mining industry, they might enjoy talking to each other about their mining days.	
Decision	Anthony thinks this is a good idea and presses "Yes" to agree to meet John.	6, 20
Implementation	The system then suggests that John and Anthony meet the next day at a local café for lunch around 1pm.	8, 38
Result	Anthony and John meet the next day and enjoy having lunch together. They enjoy talking about mining in the North-East and their experiences. They agree to meet up	

again the next week.

Use case 2: Using FriWalk features (pacing)

Section	*Narrative*	*Requirement ID*
Demographics	Isabel is an 82-year-old woman who has lived alone for the past two years	
Location	She lives in a flat by herself in Newcastle.	
Lifestyle	She no longer goes out very often and has become very physically inactive. Her daughter brings her groceries once a week.	
Gap for activity	While Isabel used to enjoy going for walks in the local park, she no longer has anyone to go walking with.	
Desire for activity	She recalls the times she spent walking with fondness and wishes that she had someone to go walking with.	
Arrival of system	One day, she receives an invitation by mail to try out the new FriTab and FriWalk system. After receiving the system when a researcher visits her, she tells the system about her background and interests. She tells the system that she used to enjoy walking.	16
Recommendation	Later that day, the FriTab suggests that she meet a lady in the next street, Martha, who likes to visit the local shopping mall and has similar mobility problems.	5, 8, 19, 10
Basis for recommendation	The system has noticed that Isabel does not have many friends and believes that if she had a friend who also enjoyed going for walks, she might go there again.	
Decision	Isabel is hesitant at first but after speaking to Martha by email and then video-link, she then agrees to meet up and try out the FriWalk.	11, 20, 39
Implementation	The FriTab tells Isabel to meet Martha the following Wednesday at 10am to enjoy a morning together at the shopping mall	12
Using FriWalk features	Once she arrives to the shopping mall, the FriWalk shows the directions to get in touch with Martha at the prescribed time. Since Martha has a similar FriWalk, the two ladies meet without any problem. Isabel and Martha go for a walk in the mall and decide to buy some groceries. The FriWalk suggests the route and monitor the execution of the activity, which is based on medical prescriptions. The FriWalk sets a comfortable pace for them to walk at. During the walk, the FriTab realises that Martha feels a little bit tired and suggests to interrupt with the planned activity. The FriTab suggests Isabel and Martha to have lunch in a local cafe.	40, 58, 60, 67, 81
Result	The FriWalk devices guides them to it where they have a pleasant lunch and agree to meet up again.	

Use case 3: Using FriTab

Section	*Narrative*	*Requirement ID*
Demographics	Sarah is a 72-year-old woman who lives with her husband.	
Location	She lives in a small house in Corbridge.	
Lifestyle	Sarah enjoys living in the rural community and has a small number of friends who live nearby.	
Gap for activity	While rural life is enjoyable, she misses the days when she lived in the city and there was more to do.	
Desire for activity	She wishes that she could get involved in more activities in Newcastle.	31, 32
Arrival of system	One day, Sarah receives an invitation by email to try out the FriTab system. Someone visits her and helps her to set up the system. She tells the system about her local	

	friends and that she would like to take part in more activities.	
Recommendation	Shortly after entering the information, the FriTab tells her that the U3A is holding a meeting in Newcastle on Friday. It invites her to attend and tells her that her friend, Joan, who lives nearby is also going to attend.	14, 21
Basis for recommendation	The system believes that U3A would be an ideal place for Sarah to get involved in various activities.	
Decision	Sarah has never heard of the U3A before and asks her friend who tells her about it. She thinks it is a good idea.	
Implementation	The FriTab tells her that the U3A meets on Friday at 11am so she would need to get the 9:57 service from the train station to get there on time. It tells her that she should leave the house at 9:35 to get there on time.	15, 42
Result	Sarah and Joan meet at the train station on Friday and travel to the U3A where they enjoy listening to a lecture and learning about the various subgroups that they can join. They sign up for another group and look forward to visiting again.	

Use case 4: Co-ordinating activities

Section	*Narrative*	*Requirement ID*
Demographics	Tom is a 68-year-old man who lives with his wife.	
Location	Tom lives in Byker, Newcastle.	
Lifestyle	Tom has quite an active social life and enjoys meeting new people.	
Gap for activity	He is a volunteer in the Hancock Museum and often invites friends to see the exhibits.	
Desire for activity	He often wonders how he can find other people who would be interested in visiting the museum.	
Arrival of system	One day, Tom volunteers to try out the FriTab system. He is shown how to use it and he enters his background information and interests. He also selects that he coordinates some events at the museum.	
Recommendation	The system then shows Tom a list of local people who are interested in natural history. It suggests that he invite them to the museum. He sends them all a message inviting them to come and visit the museum.	23, 24, 22
Basis for recommendation	The system chooses the people because they expressed an interest in natural history and believes that they would enjoy seeing the exhibits in the museum.	
Decision	Three people reply to Tom and say they would like to visit the museum for a tour.	
Implementation	Tom suggests that they meet the following week on Thursday at 10am for a tour.	
Result	The following week, the group meets Tom and they enjoy a guided tour of the natural history exhibits.	

Use case 5: FriTab and FriWalk integration for museums

Section	*Narrative*	*Requirement ID*
Demographics	Michael is a 72-year-old man who lives alone.	
Location	Michael lives in Felling, Gateshead.	
Lifestyle	For the past few years, he has found mobility very difficult and he is waiting for a hip operation. Consequently, he doesn't get out much.	
Gap for activity	He used to enjoy visiting museums and now fulfils his passion for natural history by watching documentaries on TV.	

Desire for activity	He would like to be able to get out to visit the museums in Newcastle.	
Arrival of system	Someone visits Michael one day and shows him the FriTab. Michael explains to the person that he has mobility problems so can't walk for long periods of time. But the person explains the FriWalk to him which is owned by several shops, galleries and museums in the area. So Michael enters his details into the system and tells it that he has mobility problems.	27
Recommendation	The next day, the FriTab shows Michael that a tour is being organised at the Hancock Museum. It invites him to attend and tells him that there are FriWalks at the museum.	69, 2
Basis for recommendation	The system knows that Michael enjoys natural history and that he also has mobility problems. It knows that the museum owns FriWalk devices that could help Michael.	
Decision	Michael is hesitant but agrees to give it a try. So he tells the system that he will attend.	7
Implementation	The FriTab tells him when the tour starts and where in the museum it will start from.	43
Result	When he arrives at the museum, he is given a FriWalk which helps him to walk with the rest of the tour group. After the tour is over, the FriWalk even suggests a guided tour of its own that Michael can do alone. Michael is tired but decides to come back and try the guided tour another day.	79

Use case 6: FriTab and FriWalk integration for shopping

Section	*Narrative*	*Requirement ID*
Demographics	Dorothy is a 69-year-old woman who lives alone.	
Location	She lives in Blaydon.	
Lifestyle	Dorothy uses a walker to get around because she finds that it gives her confidence after her fall one year ago.	
Gap for activity	Dorothy loves shopping and likes it when her friend occasionally takes her shopping at the MetroCentre.	
Desire for activity	While she likes the MetroCentre, she is nervous about going there alone and worries that she would get lost. But she would like to go there more often.	
Arrival of system	Dorothy is shown the FriTab and told that it clips onto FriWalk devices which are available at the MetroCentre. She decides to try out the FriTab system.	80
Recommendation	Several days later, the system suggests that Dorothy visit the MetroCentre to enjoy some shopping.	
Basis for recommendation	The system has noticed that Dorothy has stayed indoors for several days and believes that she would benefit from getting out.	
Decision	Dorothy thinks that it would be a good idea and asks the FriTab for more information.	
Implementation	The FriTab suggests that she get the 2:15 bus from the nearby bus stop which will take her to the MetroCentre. It tells her that it will give her directions to the MetroCentre and will help her find her way around inside.	
Result	She gets the bus and travels to the MetroCentre. When she gets there she swaps her walker for a FriWalk and clips in her FriTab. The FriTab shows her that several shops have sales and gives her directions. When she starts feeling tired, she presses a button on the FriTab and it directs her back to where her walker is. She unclips her FriTab and it tells her where to get the bus home.	44, 61, 66, 70

Use case 7: Older user in decline and doctor notification

Section	*Narrative*	*Requirement ID*
Demographics	Fatima is a 73-year-old lady who lives with her husband.	
Location	She lives in Hexham.	
Lifestyle	She is reasonably active and enjoys using her walker to help her get around.	
Gap for activity	Fatima likes visiting her local shopping centre.	
Desire for activity	She would like to receive notifications about sales at the shopping centre so that she can visit.	28
Arrival of system	Fatima is introduced to the FriWalk at the shopping centre one day.	
Recommendation	After using the system for about a year, the system recommends that Fatima visits her doctor. She has not been for some time.	9
Basis for recommendation	The FriWalk has noticed that Fatima's gait has changed during her regular shopping trips. It has notified her doctor of this.	25, 33, 54, 55
Decision	Fatima agrees to visit the doctor.	
Implementation	She phones to book an appointment. She tells the receptionist that she wants a checkup.	
Result	Fatima visits the doctor. The doctor can see that her gait has changed and administers some tests. She then recommends some exercises for her.	13

Use case 8: Intergenerational contact

Section	*Narrative*	*Requirement ID*
Demographics	George is an 81-year-old man who lives alone.	
Location	He lives in Newcastle.	
Lifestyle	George is quite active and enjoys helping others.	
Gap for activity	He has a keen interest in acting and used to be a member of an acting group. He enjoys helping younger people develop their skills.	
Desire for activity	He would like to be a member of an acting group but is not aware of any nearby.	
Arrival of system	One day, George is introduced to the FriTab system and after entering his information, begins to use it regularly. He finds it helpful to find out about local events.	
Recommendation	One day when George is checking his FriTab, it tells him that there is a new pantomime group starting at a nearby small theatre. It suggests that he goes along to meet others.	17
Basis for recommendation	The system knows that George likes acting and believes that he would enjoy this new group.	
Decision	George agrees to go along and investigate the new group. He tells the FriTab by pressing a button to say he will attend.	18
Implementation	The FriTab alerts the rest of the group that he will attend. They tell him that they will meet on the following week on Friday at 1PM in the local small theatre.	
Result	George attends the initial meeting and is pleased to find people from various age-groups who want to take part. He enjoys working with younger people and this gives him a good opportunity to share his skills with them. Over time, he becomes a valued member of the group.	26

Use case 9: Non-personal FriTab and FriWalk

Section	*Narrative*	*Requirement ID*
Demographics	Isabella is an 89-year-old woman who lives alone.	
Location	She lives in Newcastle City Centre.	
Lifestyle	She is not as active as she used to be because her eyesight is getting worse and she worries about losing her way.	48, 49
Gap for activity	She used to like to go to large shopping centres to explore but feels daunted by the size of them.	
Desire for activity	She would like to visit larger shopping centres without being afraid of getting lost.	
Arrival of system	One day she ventures out to a large shopping centre where a member of staff encourages her to try out the new FriWalk. She doesn't have her own FriTab so she uses one that the shopping centre provides.	1, 52
Recommendation	Isabella selects her favourite shop from the list of possible shops and the FriWalk provides directions for her. It also recommends several similar shops that she might like to visit.	3, 4
Basis for recommendation	The system believes that she might like to visit other shops that offer similar products to the one she has selected to visit.	
Decision	After visiting her favourite shop, she decides to visit a similar shop recommended by the system.	
Implementation	The FriTab and FriWalk give her directions to the similar shop.	
Using FriWalk features	As she follows the directions, the FriWak is able to gently steer the wheels in the right direction. At one point, she is veering towards a crowd of young people standing in the mall. But the FriWalk sees the group and gently steers her round it.	57, 58, 59
Result	After exploring the shopping centre with the help of the FriWalk, she is impressed with the abilities of the system and thinks she will use it again. It makes getting around the large shopping centre much easier.	

Use case 10: Rehabilitation and social use

Section	*Narrative*	*Requirement ID*
Demographics	Manuel is a 74-year-old man who lives alone.	
Location	He lives in an apartment in Madrid.	
Lifestyle	He recently suffered a bad fall which has made it difficult for him to get around. He is undergoing therapy at a local falls clinic and is slowly getting better. At the clinic he is given a FriWalk to help him move around and to give him exercises to perform at home.	
Gap for activity	Back at home, Manuel is now afraid to go out. He worries that he might fall with no one to help him.	
Desire for activity	He would like to go back to his local museum because he has not been there since his fall.	
Recommendation	One day, the FriTab on his FriWalk says that he should go to the local museum. It tells him that his friend, Francisco, who also has a FriTab, is going to the museum and they could go together.	
Basis for recommendation	Every day, the FriWalk has asked Manuel to do exercises to help improve his balance. It has noticed that his balance has improved. It thinks he will be able to go out without the help of his FriWalk.	75
Decision	Manuel agrees to go to the museum. He feels reassured by the help of his friend.	
Implementation	The next day, Francisco visits Manuel's house and they	

	walk to the museum together.	
Result	They both enjoy their visit to the museum. Because Manuel can see where his friends are going on his FriTab, he decides he will try to go out with them more often.	

Use case 11: Functional decline

Section	*Narrative*	*Requirement ID*
Demographics	Manuela is an 83-year-old woman who lives with her husband	
Location	She lives in a nursing home with her husband in Getafe, Madrid	
Lifestyle	She has been slightly depressed since she and her husband moved to the nursing home. She has lost some sight during the last years, and she does not know her way around the new neighbourhood or the venues and activities there.	
Gap for activity	She is unmotivated, she does not know the surroundings of the nursing home where she is living and does not feel confident enough to go outside the nursing home without her husband.	
Desire for activity	She would like to feel more confident to perform activities on her own, and to regain some independence.	
Arrival of system	After Manuela has suffered a fall, she has a visit with Dr. Sánchez, her geriatrician. Dr. Sánchez knows that Manuela lives in a nursing home that has some FriWalks. Dr. Sánchez sets up an exercise plan for Manuela that she can do at the nursing home.	13
Using FriWalk features	Some mornings, while her husband is out with their friends, Manuela goes to the gym in the nursing home. The nursing home counts on 2 FriWalks that are shared among all residents subscribed to an exercise program. When one of the FriWalk gets available, Manuela takes it and “logs in”. The FriWalk guides her through her exercise program. Once she finishes, the FriWalk asks her how she has been.	45, 52, 56
Recommendation	After performing an exercise session at the nursing home, the FriTab in the FriWalk tells Manuela that a group of people from the nursing home will be attending a watercolour expo near the nursing home, in a venue she did not know.	
Basis for recommendation	Manuela has regained a good functional status, and she should start doing activities on her own.	
Decision	Manuela has regained a good functional status and feels more confident about her walking capacities, so she agrees to go to the watercolour expo. Afterwards, she uses the apps on the FriTab she has been given to learn more about painting.	41

Use case 12: Rehabilitation after hip fracture

Section	*Narrative*	*Requirement ID*
Demographics	Jose is an 80-year-old man who lives alone	
Location	He lives in a small, old flat in Getafe, Madrid	
Lifestyle	José was quite active before the fracture, and enjoyed going in the morning to a bar near his house with his friends.	
Gap for activity	José is feeling some pain when he walks, and he does not know how much exercise would be good for him.	
Desire for activity	José has the idea that everyone he knows that has	

	suffered a hip fracture has died in the following year, and he is scared it might happen to him.	
Arrival of system	José starts using the FriWalk in order to stand up and walk through the hospital alleys. When he is discharged, the geriatrician recommends José with a Day Centre near his house where they have some FriWalks, as José lives far from the Hospital and it would take him too long to follow the exercise program at the Day Hospital. The geriatrician then sets an exercise program for José.	71, 78
Using FriWalk features	José goes to the Day Centre three times per week early in the morning. There, he uses the FriWalk to perform the recommended exercise program. He can also notify Dr Sánchez whether he feels pain or not, and how tired he has felt after the exercise. When he is at home again, the FriTab reminds him to take his medication on a regular basis.	37, 47, 53
Basis for recommendation	It is extremely important to regain a good level of functional capacity after a hip fracture in order to avoid disability and even death. Factors that might hinder the performance of exercise include pain or fear or falling, so the FriWalk can help to relieve these.	

Use case 13: Rehabilitation tracking

Section	*Narrative*	*Requirement ID*
Demographics	Ana is a 76-year-old woman that has some blood pressure problems. She lives in a nursing home and needs a crutch to walk.	
Gap for activity/system intervention	One day she went to the supermarket and did not see the step of the sidewalk. She felt and broke her hip. She was taken to the hospital and had to wait 4 days to have an operation, since she was taking medicines for the blood pressure and the treatment had to be interrupted. She spent 3 more days at the hospital after surgery, and when the surgery wounds allowed it she went to the functional recovery unit for rehabilitation instead of going back to the nursing home as she was not able to stand up immediately.	
Arrival of system	After the rehabilitation at the hospital she can stand up with a FriWalk. She has received training on the type of exercises she has to do with the FriWalk and she goes back to the nursing home.	
Using FriWalk features	She must perform a series of exercises every day and the summary of those exercises will be reported to the geriatrician. The geriatrician notices that Ana is not doing her exercises. She feels unmotivated after the fall, because of the pain she feels and also because she is afraid of falling again. The geriatrician contacts the nursing home personnel and they try to educate and motivate Ana to do the exercises.	37, 72, 73, 74, 76, 77
Result	She feels better after this talk and in the subsequent revisions one month (surgery) and three months the geriatrician realizes that she is improving. The feedback from the FriTab on her progress encourages her. The monitoring continues until she goes back to the hospital for the revision, after one year from the surgery. She is able to do the same activities she did before the fall, using the FriWalk. Without being monitored with the FriWalk, probably the rehabilitation would have taken more time and this woman would have not recovered well from the fracture.	46

Use case 14: Rehabilitation and activity integration

Section	*Narrative*	*Requirement ID*
Lifestyle	David has recovered from a fracture and currently he is able to walk assisted by a normal walker.	
Gap for activity/system intervention	However, he does not really want to get out of home because he is afraid of a new fracture and he feels insecure in crowded environments.	
Recommendation	This morning he received a recommendation from his Fri-Tab consisting of a visit to the temporary exhibition on model airplanes, which he loves, at the Museum that is around the corner. This museum offers FriWalks for people like David, that need a walker and do not feel very comfortable in that kind of environments	
Decision	He decided to give it a try.	
Using FriWalk features	When David reaches the museum, he parks his walker and takes a FriWalk, where he connects his FriTab. The museum is huge and there are many people, so David selects on his FriTab the icon to start the navigation to the temporary exhibition. The best route is calculated. The system is able to detect that a corridor has been closed due to building works, so it skips that route, and selects a trajectory through a big hall. In the hall a group of people is converging on a new picture so the FriWalk avoids this area. When he arrives at the exhibition he moves freely through the halls and corridors enjoying the visit. He meets an old friend who is also fond of model planes and spends some time having a nice chat with him. David now wants to look for attendance personnel to ask some questions about the models and his possibility of buying some items at the store so he selects the attendant button on the FriWalk and is redirected to the nearest one. He finally decides to go to the shop, selects “museum shop” button and the FriWalk helps David reach there, where he buys some presents for his grandchildren.	
Result	After that he goes back home. He has enjoyed the morning. David’s main activities are recorded and summarized and a short video is sent to his daughter who is the contact person in the system. She receives a video containing his father walking out of the home, reaching the museum, socializing and buying items. She is glad to see how her father is not getting isolated at home.	35, 36

1.6. User requirements table

Given the scenarios describing what the system has to achieve, we worked through what requirements this set for the system and extracted them into the table below.

ID	Part of system	Feature	Requirement
1	FriTab	User profiles	Operates with user profiles
2	Activity Generator	Data	Be aware of where available FriWalks are located
3	Activity Generator	Data	Matches shops based on similarity to each other (i.e. they sell similar products)
4	Activity Generator	Recommender system	Recommends similar shops to user
5	Activity generator	Recommender system	Make recommendations for activities based on stored information about previously enjoyed activities and stated interests
6	Activity generator	Recommender system	Allow users to accept or reject recommendations

ID	Part of system	Feature	Requirement
7	Activity generator	Recommender system	Remember users' previous history of rejects and accepts in order to learn preferences.
8	Activity generator	Recommender system	Provide geographically localised recommendations
9	Activity generator	Recommender system	Recommends visits to medical professional based on physical activity/performance decline
10	Activity generator	Recommender system	Recommend fitness-appropriate activities for users
11	Activity generator + FriTab	Recommender system	Be persuasive in encouraging users to adopt recommendations
12	Activity Planner	Data	Be aware of users' activity plans in order to avoid clashes in recommendations.
13	Activity planner	Data	Medical professionals can provide recommendations to for specific users
14	Activity planner	Information	Display activity-plans of users to specific others depending on privacy profile
15	Activity planner	Planner	Use local transport information to schedule transport to activities
16	CPSN	Data	Record background information of users (– health, interests and occupational history) in order to match users with suggested friends and provide activity recommendations
17	CPSN	Data	Store and disseminate information about public meetings in the local area
18	CPSN	Data	Record attendance of users at public meetings
19	CPSN	General	Provides a mean to maintain communication with existing friends and family and generate new friendships based on location and/or common interests.
20	CPSN	General	Can be used as a means of safe introduction before meeting new people face to face.
21	CPSN	Networking	Allow users to have lists of friends or acquaintances
22	CPSN	Networking	Allow users to create group meetings
23	CPSN	Networking	Allow users to communicate with groups of people with certain interests
24	CPSN	Networking	Allow users to send messages to other users
25	CPSN	Networking	Sends some data to medical professional based on privacy profile
26	CPSN	Networking	Includes older and younger users in social network. Younger users should be interested in meeting older people.
27	CPSN	Personalisation featuresData	Be aware of mobility problems of users
28	CPSN	Personalisation featuresData	Records shop preferences
29	CPSN	Personalisation featuresNetworking	Link users with similar interests
30	CPSN	Personalisation features	Provide questions about interests and background for initial user setup via FriTab
31	CPSN	Personalisation features	The distance the user is willing to travel for activities
32	CPSN	Personalisation features	Transportation mode availability/preferences
33	CPSN	Privacy	Privacy settings can be controlled via FriTab interface
34	CPSN	Privacy	Users should be able to withdraw themselves and their data at any time from the system for any reason

ID	Part of system	Feature	Requirement
35	CPSN	Privacy	Users should be able to specify how much information they reveal and to whom
36	CPSN	Privacy	Users should be protected from revealing too much information about themselves
37	FriTab	Activity evaluator	Collect data about user engagement and satisfaction with activities to adapt future recommendations
38	FriTab	Calendar	Contains time for appointments, social events, family and friend dates (e.g. birthdays)
39	FriTab	Communication	Email and video-calling should be provided
40	FriTab	Data	Be aware of user's location
41	FriTab	Games	Can be used to enhance attention and memory and for general entertainment
42	FriTab	Information	Communicate potential transport information to user
43	FriTab	Information	Be able to provide navigation instructions in public spaces
44	FriTab	Information	Be able to guide user back to starting location and home with easy-to-follow instructions
45	FriTab	Information	Display exercise instructions to users with motivation feedback
46	FriTab	Information	Display data about amount of steps, distance, etc. after each activity and relation to targets
47	FriTab	Input	User can tell system that they no longer want to do an activity and why in order to personalise future recommendations
48	FriTab	UI	Display accessible visual user-interface for CPSN. Visual impairments must be considered.
49	FriTab	UI	Provide a non-graphical visual interface for users with visual impairments
50	FriTab	UI	Interaction very easy
51	FriTab	UI	Interface must not irritate, distract or block view.
52	FriTab	User profiles	Can operate with different user profiles (including guest profile) guest user profile
53	FriTab (rehab)	Reminder system	Doctor can provide time and dosage information to system to notify users to take medication
54	FriTab + FriWalk	Data	Track life-space mobility. Alert carer/doctor if it is reducing.
55	FriTab + FriWalk	Data	Track walking distances. Alert carer/doctor if speed is slowing or gait is changing.
56	FriTab + FriWalk	User profiles	Should recognise user and adapt to their profile accordingly
57	FriWalk	Data	Monitors immediate environment for presence of people in order to avoid collisions
58	FriWalk	Guidance	Provides navigation prompts in public spaces
59	FriWalk	Guidance	Avoids collisions with objects and people
60	FriWalk	Information	Communicate walking pace to another user if permitted by user
61	FriWalk	Physical form	Adjustable height for individual users
62	FriWalk	Physical form	Should not require tight/strong grip
63	FriWalk	Physical form	Stable, robust and heavy enough to avoid falls. Should be perceived as sturdy.
64	FriWalk	Physical form	Should not be able to lift it when turning.
65	FriWalk	Physical form	Easy to manoeuvre
66	FriWalk	Physical form	Seat for user
67	FriWalk	Recommender system	Set up with different activities for different users.

ID	Part of system	Feature	Requirement
			Personalised exercises to improve balance and strengthen muscles.
68	FriWalk	Usage	Can be used outdoors in close vicinity to the hospital or museum (or other key location) with reduced functionality
69	FriWalk (generic)	Availability	Be located at key locations such as shopping centres, museums and sports centres.
70	FriWalk (generic)	Physical form	Should be able to carry some a few items of shopping for the user
71	FriWalk (rehab)	Availability	Be located at hospitals or clinics.
72	FriWalk (rehab)	Data	Monitors user gait
73	FriWalk (rehab)	Data	Monitors user posture
74	FriWalk (rehab)	Data	Monitors user speed
75	FriWalk (rehab)	Data	Monitors user's balance
76	FriWalk (rehab)	Data	Monitor posture and distance from walker. Correct user if necessary
77	FriWalk (rehab) + FriTab	Information	Recommend that user changes posture during an activity
78	FriWalk (rehab) + FriTab	Recommender system	Recommends exercises to users
79	FriWalk + FriTab	Information	Be able to provide guided tours of public spaces such as museums
80	FriWalk + FriTab	Physical form	FriTab should be able to easily attach and detach from FriWalk
81	FriWalk + FriTab	UI	Haptic feedback will be provided available to users if they desire

1.7. Conclusion and Next Steps

These are top level requirements of the system discussed with potential users via user scenarios. The requirements focus on the need to provide a FriWalk with the ability to support rehabilitation and frailty; a FriTab with the ability to access a social network, recommendations and activity data; and a social network (CPSN) that can link users together based on shared interests, provide the ability to communicate, and preserve the privacy of users.

Using user scenarios is a valuable way of highlighting requirements and also reminds developers of what they are aiming to achieve.

The next steps in the process are as follows:

- Discuss the requirements with the team and identify the functionality required to achieve the requirements.
- Develop the scenarios into animations and discuss the scenarios with older adults, and other stakeholders including carers and businesses such as museums and iterate the requirements where necessary.

Appendix 1: ACANTO preliminary clinical requirements for the FriWalk

Getafe Clinical Workshop discussion and minutes

The workshop started with an introduction by the health professionals at the Geriatrics Service of the University Hospital of Getafe, where the Head of the Service, a geriatrician and the occupational therapist of the Day Hospital described the usual workflow with patients.

After hospitalization after an acute event or after a visit to the geriatrician, patients can be referred to the Day Hospital in case the geriatrician considers that they are eligible for participating in a functional rehabilitation program. Patients are eligible depending on their acuteness level and the foreseen impact that the rehabilitation program might have on their health status. The decision to enroll patients is agreed between the geriatricians and the occupational therapist, according to the aforementioned parameters. Patients that are finally enrolled undergo a 16-session rehabilitation program under the supervision of the occupational therapist. The program starts with an evaluation of the functional status of the patient, through the realization of a battery of tests that aim to realize a multifactorial assessment of the functional, health and mental status of the patients. Each session comprises a set of physical and cognitive exercises, adapted to each patient. There are no pre-defined set of exercises adapted for different patient profiles; personalization is realized based on the experience and insights of the occupational therapist.

After the patient has completed the 16-session program, they are evaluated again using the same battery of tests as the one performed at the beginning. The results of these battery of tests and the evolution of the patient are analyzed in periodic meetings by a multidisciplinary team in the Geriatrics Service, including the geriatrician, nurses and occupational therapist. During this meeting, it is decided how to proceed next with each patient: it the patient has regained an acceptable functional level, they are discharged and regular meetings are appointed. There is not a monitoring program of the functional status of the patient in between regular visits. On the other hand, if the patient has not regained an acceptable functional level, they can be re-enrolled to attend more sessions.

During the discussion, the ACANTO partners identified three points in the care process of older adults adopted in the Geriatrics Service of the University Hospital of Getafe where the FriWalk could be of use:

1. **Falls prevention and rehabilitation**. Many of the patients who attend the rehabilitation program are recurrent fallers, or are enrolled in order to recover their confidence and functional status after a fall. The FriWalk could be then used in order to motivate patients to keep an active lifestyle and to overcome fear or falling by improving their strength and balance.
2. **Diagnosis and monitoring**. The FriWalk could be used in order to assess the functional status of the patient without having to acquire the expensive equipment available at the Geriatrics Service of the University Hospital of Getafe (posturographer, gait rite, etc.).
3. **Continuous, long-term monitoring**. The FriWalk could be used in order to motivate patients to keep a healthy lifestyle, as well as to keep track of their functional status in-between visits.

It was then decided that the latest two scenarios could be considered as the most promising for

their implementation within ACANTO. Then, two parallel groups including partners from different backgrounds (each group should comprise at least 1 health professional, interaction designers and technical partners) were organized in order to discuss in depth each scenario, and to analyze the benefits of using the FriWalk.

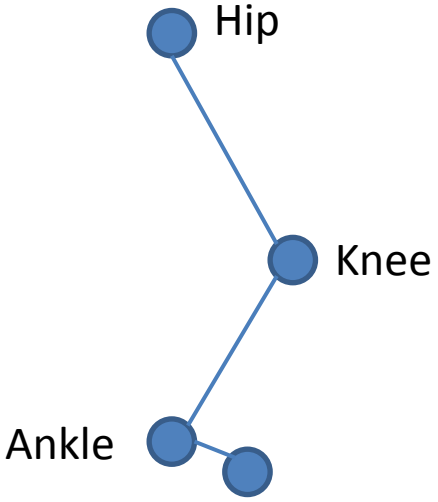
Results and conclusions on the group discussion "Diagnosis and Monitoring"

A) Gait pattern analysis has been the core topic of the discussion. Several parameters of relevance have been identified on the gait pattern:

- the length of steps
- the frequency of steps
- the lateral motion of the body while walking
- the force that is applied on the handles (i.e. not to be confused with the gripping force but the downforce on the ground) including its symmetry as a possible indication for an imbalance while the force by itself is an indication of the muscle strength in the arms versus the muscular strength in the legs.
- whether a patient crosses the feet during the walking pattern or not
- whether a patient drags his feet on the ground

The group discussed a technical approach to derive these and practically any relevant parameters of the gait from an **intermediate level representation** that consists of:

- An **animated skeleton** of the **two legs** that covers the following joints for each leg:



Each of the joints will be measured in 3D-coordinates. The results in a first iteration will be an animation of such a skeleton model for visual diagnosis. The sensor will be a 3D-camera observing the feet.

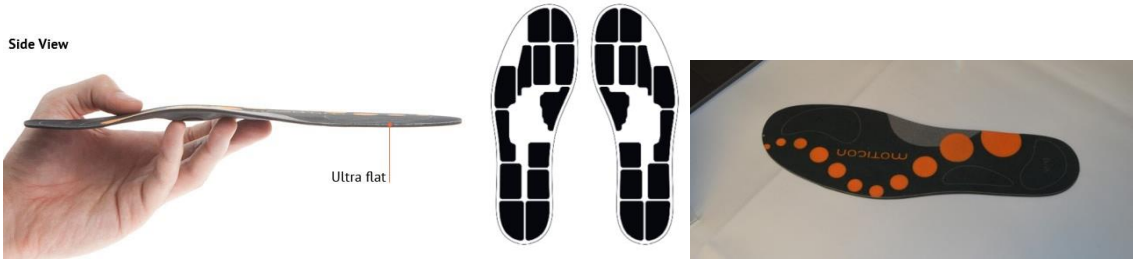
In a bilateral follow-up discussion during dinner the idea was generated that it is actually sufficient to measure only the space angles while the length of the lower or upper leg is known for a given individual in advance by its anatomy. This is especially advantageous for estimating the hip joint which is considered to be difficult to measure from the 3D data.

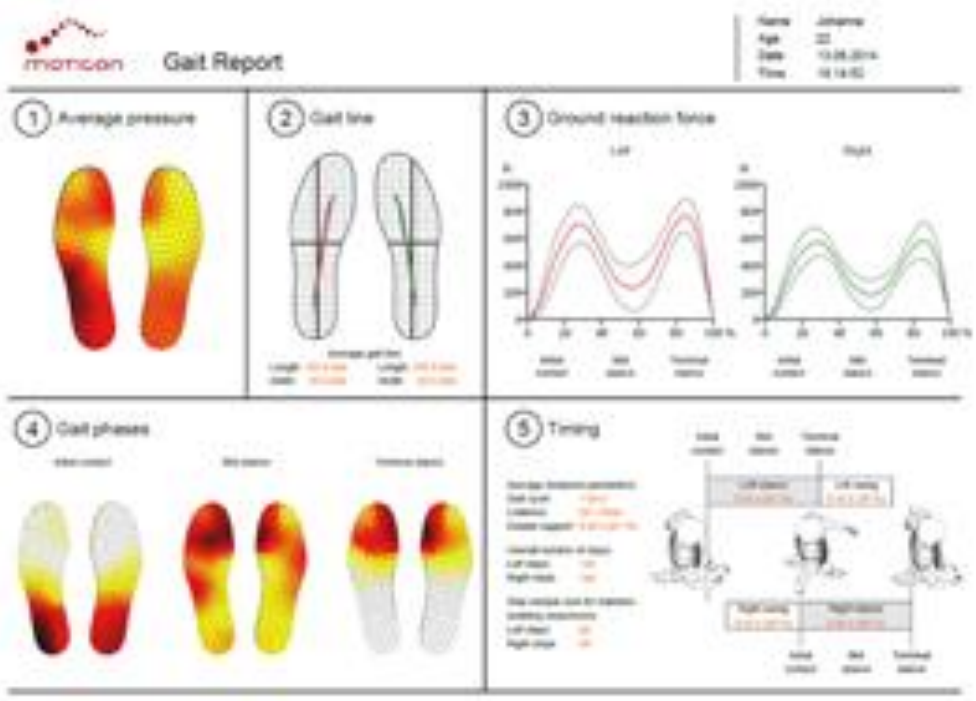
The other group raised the valid point that it would be useful to verify in advance the suitability of such representation with a more expensive system before investing efforts in its development. Particularly at the University of Northumbria equipment is available

for professional analysis of sport activities. This idea will be further investigated.

- A sensing device for **measuring the pressure distribution on sole of foot**. This will be most likely be an insole (inlay) sensor and we will look for such solutions (commercially) available on the market.

Just to give one examples of many:





Source:

http://www.gizmag.com/moticon-sensor-insoles/30920/
http://www.moticon.de/
http://www.moticon.de/products/physio-pro-sports

- Sensors **measuring the downforce applied on each walker handle**

A) Facial Expression Analysis has been identified to have potential to reveal several relevant conditions like:

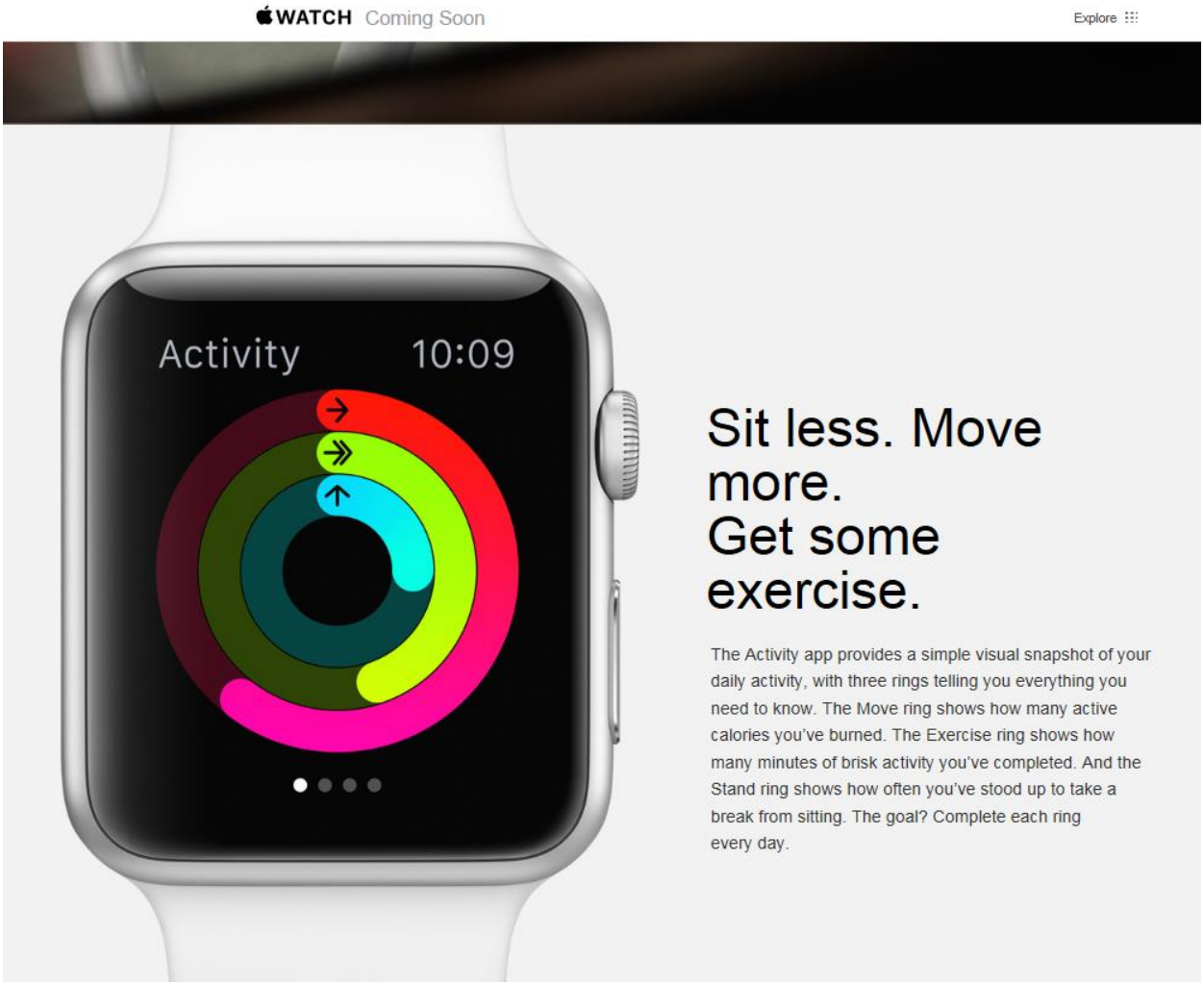
- Early warning sign of potential **dementia**: Facial expression variation of an individual over time
- **Sleep Apnea**: Measurement of eye blinking frequency - similar to driver monitoring in cars - as an indication of sleepiness

Especially for the facial expression variation it has been concluded that there is quite a large variance across people, so the inter-class variance might be higher than the intra-class variance. Anyhow the problem can be tackled by calibrating the sensor on the individual, i.e. observe over

a certain amount of time the regular behavior and try to detect deviations from this behavior (anomaly detection).

A) Generation of **Activity Statistics**:

One example given was the generation of statistics as advertised for the upcoming Apple Watch, which is rather easy to be derived from basic sensors - especially in case of a wearable (watch, fitness tracker, wristbands) with dedicated sensors.



Source: http://www.apple.com/watch/health-and-fitness/

The other term discussed was « **Life Space** ». Essentially it means the radius of activities and visited places and hence the activity level of a person and its variance. This can be measured in a micro-scale like the own home (AAL) but for us in ACANTO it is of higher interest to rate out-of-home activities which we aiming to prolong.

B) Finally the group discussion addressed **self-assessment/testing** as well as exercise functionalities.

Some of the tests shown in Getafe can be rated automatically, like the getting-up test from a chair with folded arms, as well as the walking speedometer.

One idea of FORTH goes in the direction of using the front camera for such purpose, so the walker is turned to view the elderly person. That way the front camera can observe the whole body and derive a kinematic model from this view which is a successor of the background-work of FORTH carried out for the upper body.

Also it has been discussed to modulate the resistance of the walker (e.g. by steering the breaking force of the wheels) for the purpose of either muscle strength assessment or exercising.

Results and conclusion of the group discussion "Monitoring"

A) The core of the discussion was dedicated on addressing how the FriWalk could be used to **improve the functional status** of the patients after they have been discharged from the rehabilitation program.

It was agreed that the FriWalk provides a great opportunity for training older adults to maintain their capabilities. In this sense, a twofold approach was discussed:

- The system could provide patients with an **exercise program** aimed to maintain and/or improve their level of working muscle and hence the functional status of the patient. The exercise program should aim at two main goals:

o Maintaining/Improving **Balance**. Currently, the following exercises are recommended in the Day Hospital oriented to improve balance: (1) tiptoe, (2) walking on heels, and (3) walking on sand or on a soft foam material. The medical professionals suggested that it would be useful that the system would be able to provide patients with tools to correct their posture when they are at home. Hence, the system should be able to capture the posture of the patient when using the walker, to detect any anomalies with respect to their baseline posture, and to provide the patient with feedback and tips aimed to correct their posture. Different technological approaches were suggested by the technical partner, including audio/visual feedback (similar to parking assistance in modern vehicles), or the use of the FriTab as a mirror with augmented reality techniques in order to suggest corrections to the posture.

o Maintaining/Improving **Strength**. The system should provide tools for improving the strength and resistance of the patients and hence allowing them to walk longer and faster. Currently, exercises for improving strength include activities such as climbing and going down stairs or using a bicycle pedal. In order to achieve similar results, two types of exercise using the walker were suggested:

▪ Walking without resistance. Usually, patients reduce their walking pace as time advances. The walker should motivate patients to keep a constant walking pace.

▪ Working strength by simulating slopes or changing the resistance (i.e. using the brakes). This exercise would have similar effects to the exercises performed using the stairs or the bicycle pedal.

In both cases, besides the "mechanical" aspects of the exercise (i.e. using brakes to increase resistance, keeping a constant velocity), motivation plays a pivotal role, i.e. by providing patients with exercise goals and/or motivation messages encouraging them to walk faster and/or longer.

From an interaction perspective, it was considered as non-convenient the use of haptic interaction strategies such as the use of haptic actuators placed in the user's legs (i.e. vibrating every time the user

should go one step further in order to keep a steady velocity), as this kind of interaction might confuse users.

- The system could help patients with **daily outdoors activities**. In this sense, in order to achieve a long-term impact, the walker should be integrated into the patients' daily lives, recommending them with activities tailored to their needs and interests.

  During the recommended outdoor activities, it was considered that monitoring the following parameters would be useful in order to assess the health and functional status of the patient:

- Heart rate.
- Whether the patient raises their feet when walking in a naturalistic environment or not, and the height of the step.

A) Besides functional training, **cognitive training** was considered as a fundamental aspect for improving the quality of life of adults in frailty or risk of frailty.

Health professionals stated that improving the social status of the older adults (i.e. motivating them to participate in outdoor activities with other people, either older adults or younger relatives or voluntaries) has a positive effect on their functional condition.

One of the main problems for implementing a cognitive or social training strategy is the lack of literacy of many older adults. At the Day Hospital of the University Hospital of Getafe, the occupational therapist proposes tailored cognitive training plans based on the knowledge and status of the patients; hence, an ICT-based system for implementing cognitive training should provide a high degree of **personalization**, ranging from complex, text-based cognitive exercises to simple, no-text exercises using ideograms and images. Moreover, this implementation of different levels of language should extend to the overall interaction of the system. Hence, an effort should be made in order to adequately build **patient profiles** capable of capturing the functional, cognitive and socio-economic aspects of older adults, while ensuring security and privacy.

Meeting with the occupational therapist

Later, in late April 2015, the researchers from the Health Research Institute of Getafe held a meeting with the occupational therapist who implements the exercise programs and who assesses the status of frail older adults in the Day Hospital of Getafe. During the meeting, the occupational therapist shared with the researchers all the scales that were used to evaluate the progress of the functional status of the patients, and a discussion was held regarding the priority applications that should be implemented according to her experience.

3 priorities were agreed:

- Gait speed when using the walker.
- Gait variability (referred to as gait cycles)
- Cognitive level (simple). The system should implement cognitive training techniques, oriented to improve the cognitive status of the patient. The system should proposed patient with personalized cognitive exercises, adapted to the patient's cognitive level and socioeconomic conditions (i.e. whether the patient is literate or not).

Conclusions

Table 1 presents a summary of the most relevant variables identified during the clinical

workshop in Getafe, and establishes priorities for the implementation.

Table 1. Parameters and variables

Parameter	Variable	Sensing Techniques	Priority
Gait speed	Average speed	Velocimeter	1
	Frequency of steps	Using insoles, using camera as described in Figure 1.	2
	4-meter test speed	The 4-meter test speed needs to start with the user standing still, as the starting impulse is an important factor to ensure the validity of the measure. Therefore, the walker should use the brakes to impede any movement, and the FriTab should prompt the user with instructions to start walking (i.e. 3,2,1, like when starting a race)	1
	6-meter test speed	The walker should be able to measure the time it takes the user to walk a 6-meter distance. It is important that this is a straight walk. For application in a non-controlled environment, it would be good if the walker would be able to detect when the walker has a clear 6-meter straight path without any obstacles.	1
Gait pattern	Speed variability	Speed variability in non-controlled environments.	1
	Whether patients cross their feet when walking		3
	Whether patients drags their feet when walking		3

Parameter	Variable	Sensing Techniques	Priority
Muscle strength	Force applied to the handles		1
	Walk with different resistances	Use the brakes to simulate different resistances, i.e. slopes. The FriWalk should be able to implement different difficulty levels, to be selected by the user or occupational therpist	1
Balance	Lateral motion of the body with walking	In movement	2
	Downforce on handles difference	In movement	2
	Unipodal balance	Still, with eyes open and closed	2
	Bipodal balance	Still, with eyes open and closed	2
Posture	Whether the user leans forward		1
	Whether the user leans backwards		1
	Whether the user leans to one side		1
Cognitive status	Assessment of cognitive status	Mini-Mental on Tablet	1
Mood status	Facial expression		3

Parameter	Variable	Sensing Techniques	Priority
	Explicit input (test, questionnaire)		3
Social status	Detection of "Life Space"	Use GPS coordinates to determine whether the user makes outdoors activities, i.e. going out shopping, etc.	3
	Activity statistics		3
Other Health Conditions	Heart Rate		1
	Respiratory Rate		1
	Sweating		1
	Apnea – measurement of blinking frequency		1