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Purpose: Older people population is expected to grow dramatically over the next 20 years (including Alzheimer’s patients), while the number of people able to provide care will decrease. We present the development of medical and information and communication technologies to support the diagnosis and evaluation of dementia progress in early stage Alzheimer disease (AD) patients. **Method**: We compare video and accelerometers activity assessment for the estimation of older people performance in instrumental activities of daily living (IADL) and physical tests in the clinical protocol developed by the Memory Center of the Nice Hospital and the Department of Neurology at National Cheng Kung University Hospital – Taiwan. This clinical protocol defines a set of IADLs (e.g., preparing coffee, watching TV) that could provide objective information about dementia symptoms and be realistically achieved in the two sites observation room. Previous works studied accelerometers activity assessment for the detection of changes in older people gait patterns caused by dementia progress, or video-based event detection for personal self-care activities (ADLs)[1, 2, 3], but none has used both sensors for IADLs analysis. The proposed system uses a constraint-based ontology to model and detect events based on different sensors readings (e.g., 2D video stream data is converted to 3D geometric information that is combined with a priori semantic information, like defined spatial zones or posture estimations given by accelerometer). The ontology language is declarative and intuitive (as it uses natural terminology), allowing medical experts to define and modify the IADL models. The proposed system was tested with 44 participants (healthy=21, AD=23). A stride detection algorithm was developed by the Taiwanese team for the automatic acquisition of patients gait parameters (e.g., stride length, stride frequency) using a tri-axial accelerometer embedded in a wearable device. It was tested with 33 participants (healthy=17, Alzheimer = 16) during a 40 meters walking test. **Results & Discussion**: The proposed system detected the full set of activities of the first part of our clinical protocol (e.g., repeated transfer test, walking test) with a true positive rate of 96.9 % to 100%. Extracted gait parameters and automatically detected IADLs will be future analyzed for the evaluation of differences between Alzheimer patients at mild to moderate stages and healthy control participants, and for the monitoring of patients motor and cognitive abilities.

Keywords: Information Technology, Health & self-esteem, multi-modal sensors monitoring systems, Alzheimer’s disease, dementia, elderly, older people

INTRODUCTION

The older people population is expected to grow dramatically over the next 20 years, and the number of people requiring care will grow accordingly (including Alzheimer’s patients), while the number of people able to provide care will decrease[1].

Information and Communications Technologies (ICT) have been proposed to improve and support older people care (*e.g.*, wearable sensors, smart-homes, video monitoring systems). For instance, wearable sensors measurements have been proposed for medical diagnosis trials on the evaluation of older people motor functions[2-3]. The patients wore a chest or wrist sensor during a gait analysis test to extract kinematic parameters for gait patterns analysis (*e.g.,* stride length, stride cadence). The extracted kinematic parameters were used as evidence to evaluate existing differences between gait patterns of health participants and patient diagnosed with dementia (Alzheimer’s disease patients at mild to moderate stage). Similar ICT applications were applied and studied for the analysis of Parkinson’s disease impairments, *e.g.*, force-plates placed below patient gait test path [7] and accelerometer-based wearable devices [6]. This approach could be also explored for the study of patient activity patterns in activities of daily living (*e.g.,* dressing, eating). Although wearable sensors are suitable for description of personal kinematics parameters, they do not provide data about a subject’s actions over his/her environment (contextual data). For example, a person’ interaction with household appliances (coffee making machine, TV, *etc*), or his/her time spent in certain home areas (*e.g.*, kitchen, bedroom, living room).

Video-based system for older people surveillance is growing as a research field (particularly frailty detection) [9-13], as it can provide data about a people interaction with their environment (*e.g.*, time spent in zones and interaction with objects of interest). Applications are generally associated with detection of daily living activities (*e.g.*, eating, dressing, walking), or the detection of (potentially) dangerous situations (*e.g.*, older people falls). But, for particular domotic environment, illumination conditions, or camera field of view, these systems could have problems in characterizing a person's postures (*e.g.*, bending to an object), or at quantifying an impairment in a limb movement *(e.g.,* a restricted range of motion). Higher resolution video cameras or multiple cameras arrays could be applied in this case, but they will increase the ICT project cost and complexity.

To address the above limitations of current systems, we present the first results of the SWEET-HOME project, an initiative focused on the development of a medical and ICT-based system for the improvement of diagnosis and evaluation of dementia progress in early stage Alzheimer's Disease (AD) patients.

We attempt to overcome the described limitations of the sole use of video or wearable sensors by deploying several sensors types (video and accelerometer) for our clinical tests analysis. These sensors were tested inside a clinical protocol developed and executed by the Memory Center of the Nice Hospital – France and the Department of Neurology at National Cheng Kung University Hospital – Taiwan.

The clinical protocol is intended to assess older people performance in IADLs (Instrumental Activities of Daily Living, *e.g.*, preparing coffee, watching TV) and in gait analysis tests (*e.g.*, performing a balance test). IADLs are preferred to ADLs, as IADLs have been recently addressed as better indicators of emerging neuropsychiatric symptoms [5]. ADLs generally refer to basic activities of personal self-care (e.g., eating, dressing, washing), while IADLs are associated with more complex tasks, *e.g.*, using the telephone, shopping groceries, organizing medications, and managing personal finances. IADLs seem to be affected earlier than ADLs for early stage Alzheimer patients. We postulate that comparing data from several sensors could provide new (or at least complementary) quantitative evidence about changes in a patient's activities profile[5]. The clinical protocol' activities were specifically chosen according to their possibility of being realistically achieved into the observation room of the hospital and at the same time provide objective information about dementia symptoms.

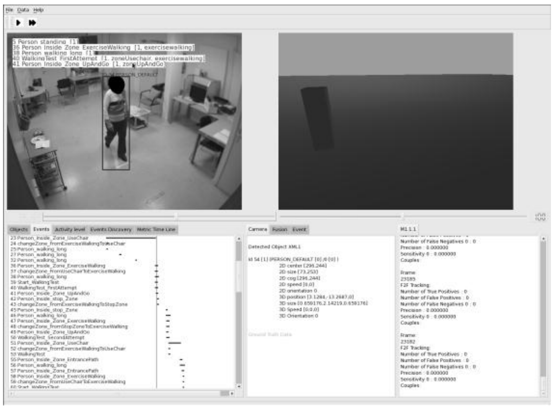

Figure1. Video monitoring system results being analyzed by the evaluation platform (VISEVAL) developed by the STARS team (France).

MATERIALS AND METHODS

This multi-centric study was carried out in French and Taiwanese experimental sites. Experiments in France took place in an observation room equipped with household appliances. Experimental data was recorded using a 2D video camera (AXIS®, Model P1346, 8 fps - frames per second), and an ambient audio microphone (Tonsion, Model TM6, Software Audacity, WAV file format, 16bit PCM/16kHz). A motion sensor (*e.g.*, MotionPod®) was fixed on the chest of the participant to quantify their movements. MotionPod® sensor provides an index of activity and estimation about the patient posture (standing, sitting, lying, walking), both of them with a resolution of 1 data per second.

The Taiwanese experiments took place in indoor and outdoor environments. For the indoor experiments a room equipped with household appliances was used and experimental data was recorded using eight ambient 2D video cameras (AXIS, Model 215PTZ, 30 fps). For outdoor experiments a tri-axial accelerometer mounted on the shoes of the participants was used to analyze their gait parameters

Clinical protocol

The Clinical Protocol is divided into four scenarios: directed activities (indoor), semi-directed activities (indoor), undirected activities (indoor), and directed activities (outdoor).

Scenario 01 (S1) or Directed activities in an indoor environment is intended to assess kinematic parameters about the participant's gait profile (*e.g.*, static and dynamic balance test, walking test). During this scenario an assessor stays with the participant inside the room and asks him/her to perform seven physical activities within 10 minutes. These activities are briefly described as follows:

- Balance testing (S1_A1-A4): the participant should keep balance while performing the following actions:
  - Side by side stand (S1_A1): both feet together,
  - Semi tandem stand (S1_A2): stand with the side of the heel of one foot touching the big toe of the other foot,
  - Tandem stand (S1_A3): stand with the heel of one foot touching the toes of the other foot,
  - Participant stands on one foot (S1_A4): Right foot first then left foot, eyes open, for ten seconds or less if he/she has difficulty.

- Walking speed test (S1_A5): the assessor asks the participant to walk through the room, following a straight path from one side of the room to another (chair side to video camera side, outward attempt, 4 meters), and then to return (return attempt, 4 meters);

- Repeated chair stands testing (S1_A6): The assessor asks the participant to make the first posture transfer (from sitting to standing posture) without using help of his/her arms. The examiner will then ask the participant to repeat the same action five times in a row.

- Time Up & Go test (TUG – S1_A7): participants start from the sitting position, and at the assessor's signal he/she needs to stand up, to walk a 3 meters path, to make a U-turn in the center of the room, return and sit down again.

Scenario 02 (S2) or semi-directed activities (indoor) aims at evaluating the degree of independence of the older people by performing IADLs in a given order. The participant stays alone in the room with a list of activities to perform, and he/she has to leave the room only when feeling that has completed the required tasks (no maximum time). It includes 7 indoor IADLs to be performed in the following order:

- Reading for 2 minutes (S2_A1);
- Warming water (S2_A2);
- Making a call for phone number 34775 (S2_A3);
- Watering a plant (S2_A4);
- Watching TV (S2_A5);
- Classifying cards by color (S2_A6);
- Taking ABCD Folder in the zone Office (S2_A7a); Matching ABCD letters of the ABCD Folder with ABCD letters placed over the room (S2_A7b), Returning ABCD folder to its place (S2_A7c), and;
- Leaving the room (S2_A8).

Scenario 03 (S3) or undirected ("free") activities (30 minutes) aim at assessing how the participant spontaneously initiates activities in the room (*e.g.*, reading magazines/newspapers, drinking, playing cards, and watching TV) and also how he/she organize time without receiving specific instructions. Figure 2 shows the French indoor observation room (Scenarios 1-3).

Scenario 04 (S4) or Directed activities in an outdoor environment aim at analyzing different gait parameters using the tri-axial accelerometers and the stride algorithm developed in the project. The participant is asked to walk around the ring region in the NCKU campus (following the plan shown in Figure3). During this walking period he/she performs a simple walking test of 40 m on a straight line; and a dual task test where he/she needs to walk the same distance while counting down from 100 to 1.

Figure2. French indoor experimental room, observation room

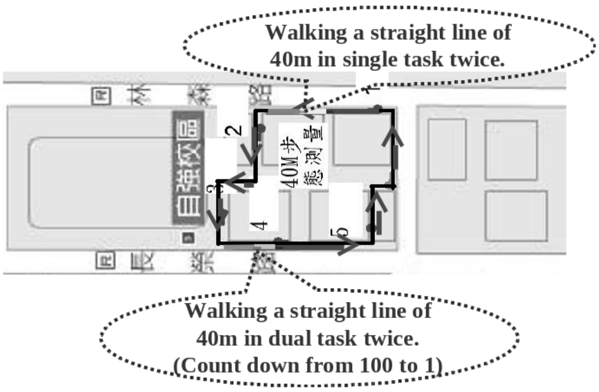

Figure3. Taiwanese outdoor experimental environment

Participants

French participants aged more than 65 years were recruited by the Nice Memory Center (NMC) of the Nice Hospital. Inclusion criteria of the AD group were: diagnosis of AD according to NINCDS-ADRDA criteria and a Mini-Mental State Exam (MMSE) score above 15. AD participants with significant motor disturbances as per the Unified Parkinson's Disease Rating Scale were excluded.

Taiwanese participants aged more than 50 years were recruited by the Department of Neurology at National Cheng Kung University Hospital. The Inclusion criterion of the AD group was a MMSE score value above 16.

Tables 1-4 describe the clinical and demographical characteristics of the participants (healthy control – HC, and AD) according to the different evaluated scenarios.

Table 1.French participants on S1

	HC (N=21)	AD (N=23)
Female, N (%)	12 (50%)	16(68.75%)
Age, years(mean ± SD)	73.4±6.09	76.7±7.84
MMSE(mean ± SD)	28.4±0.98	21.35±3.97

Table 2.French participants on S2

	HC (N=10)	AD (N=16)
Female, N (%)	5 (50%)	11(68.8%)
Age, years (mean±SD)	73.9±6.24	76.7± 7.56
MMSE (mean ± SD)	28.1±1.85	20.7± 3.70

Table 3.Taiwanese participants on S1 and S2

	HC (N=45)	AD (N=36)
Female, N (%)	24 (53.3%)	21 (58.3%)
Age,years (mean ± SD)	64.51±8,33	70.25±9.25
MMSE (mean ± SD)	27.60±2.04	23.44±3.32

Table 4.Taiwanese participants on S4

	HC(N=17)	AD(N=16)
Female, N (%)	9 (52.9%)	9 (56.3%)
Age,years (mean ± SD)	62.35±2.04	66.69±5.69
MMSE (mean ± SD)	27.65±2.40	24.19±3.62

Systems overview

Table 5 describes the sensors used to compute different parameters about older people activities (*e.g.,* duration of activity execution, gait parameters).

Table 5. Sensors used for older people activity analysis within each scenario

	France	Taiwan
S1	2D video camera (Activities annotation) Automatic Sensor Monitoring	2D video camera (Activities annotation)
S2	2D video camera Activities annotation	2D video camera Activities annotation
S4	-	Tri-axial accelerometer

Automatic Sensor Monitoring System

The proposed automatic sensor monitoring (ASM) system for activity recognition uses a constraint-based ontology to model and detect events based on the sensor data output. 2D video stream data is converted to 3D geometric information, and it is combined with *a priori* semantic information about the clinical scenario[4]. The ontology language is declarative and intuitive (as it uses natural terminology), allowing medical experts to easily define and modify the activities and gait event models (using spatial, temporal, video-tracking and accelerometer data to describe events). For example: "participant [person] is close to the chair [object1]", "participant is sitting [person height less than a given threshold]". Figure4 presents the overall system architecture.

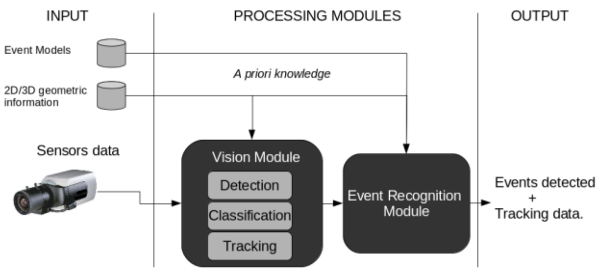

Figure4. Example of sensors based monitoring system architecture using video data [4].

Stride Detection algorithm

A stride detection algorithm was developed for the automatic acquisition of gait information (e.g., walking time, stride length, stride frequency) using a tri-axial accelerometer embedded in a wearable device (see Figure 5). The proposed stride detection algorithm chain is organized as follows: data collection, signal pre-processing, and stride detection. At the beginning of the algorithm, the acceleration signals are transmitted to a computer via the RF transceiver. Then a moving average filter is applied to remove high-frequency noises from the raw data. Finally, a threshold method is used to determine the start and end points of the strides.

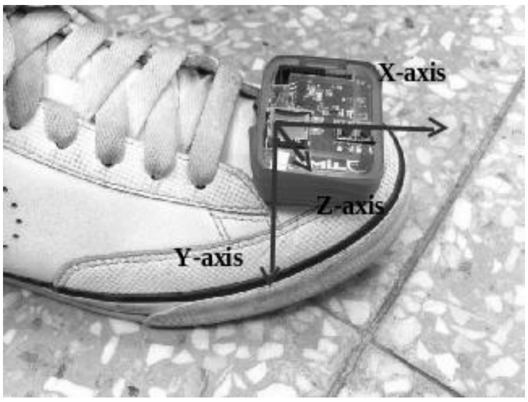

Figure 5. Proposed stride detection device

Statistical Analysis

Results are presented in terms of mean (± standard deviation) for continuous variables. For categorical variables, results are presented in terms of frequency for each modality. Intergroup comparisons for continuous variables used the parametric Student's t-test or the non-parametric Mann-Whitney test ($p<0.05$) if one of the assumptions of the Student's t-test is not satisfied. Intergroup comparisons for categorical variables (2 modalities) used the Fisher's exact test ($p<0.05$). All calculations were performed using SPSS software (version 19.0).

RESULTS AND DISCUSSION

RESULTS FOR SCENARIO 01

French experimental site

Table 7 shows the results of the French participants performing the activities of the Scenario 01. Activity' parameters were calculated using the human expert annotation about the activities in the video sequences. AD participants needed more time to complete the different physical activities due to a lower displacement speed.

Table 7. French participants' performance for Scenario 01 calculated using annotations of human expert

	HC	AD	p-value
S1_A5 -Walking speed, (Go attempt) (m/s) -Walking speed (Go back attempt) (m/s)	0.88±0.25 1.02±0.21	0.69±0.20 0.77±0.18	0.009 ** < 0.001 **
S1_A6 -Duration (s) -Duration/ number of transfers	14.90±5.75 1.50±0.58	19.7±6.79 1.9±0.63	0.012 * 0.006 **
S1_A7 -Duration (s)	10.30±4.12	14.6±6.16	0.002 **

P-values were computed using Student's t-test for the parameters of S1_A5, and by using Wilcoxon Test for the parameters of S1_A6 and S1_A7; (*) Statistical significance at p < 0.05; (**) Statistical significance at p < 0.01

The ASM system detects the full set of the guided-activities scenario (e.g., balance test, repeated sequence of sitting-standing positions) using video data with a detection rate from 96.9 % to 100% (true positive rate).

Table 8 shows the same activities parameters of Table 7, but with activity parameters calculated using the activities detected by the ASM system (36/44 video sequences, where HC=16 and AD=20). Although the absolute values of the parameters calculated using ASM results are different from the parameters values obtained from human annotations, the statistically significant differences between healthy participants and AD patients group were preserved.

Table 8. French participants' performance for Scenario 01 calculated using the ASM system results

	HC (N=16)	**AD (N=20)**	***p-value***
S1_A5 -Walking speed, (Go attempt) (m/s) -Walking speed (Go back attempt) (m/s)	1.06±0.23 1.20±0.31	0.79±0.23 0.89±0.23	0.001** 0.002**
S1_A6 -Duration (s) -Duration/number of transfers	12.8±5.40 1.3±0.53	17.7±6.31 1.7±0.56	0.006** 0.002**
S1_A7 -Duration (s)	8.8±3.80	12.1±5.64.	0.007*

P-values were computed by using Student's t-test for the on parameters of S1_A5, and by using Wilcoxon Test for the parameters of S1_A6 and S1_A7; (*) Statistical significance at p<0.05; (**) Statistical significance at p<0.01

Taiwanese experimental site

Table 9 shows the results of Taiwanese participants performing Scenario 01. Activity parameters were calculated based on the annotations of Human expert. Activity parameters of Taiwanese participants agree with the French experimental results in the sense that AD participants took more time to perform the selected activities, probably due to their lower speed of displacement when compared to HC participants.

Table 9. Taiwanese participants' performance for Scenario 01.

	HC	AD	p-value
S1_A5 -Walking speed, (Go attempt) (m/s) -Walking speed (Go back attempt) (m/s)	0.38 ± 0.08 0.41 ± 0.07	0.32 ± 0.74 0.34 ± 0.08	0.001** <0.001**
S1_A6 -Duration (s) -Duration/ number of transfers	14.5 ± 3.33 1.4 ± 0.33	20.0 ± 9.41 2.00 ± 0.94	0.001** 0.001**
S1_A7 -Duration (s)	10.2 ± 2.42	13.4 ± 3.34	<0.001*

P-values were computed using Student's t-test for parameters of S1_A5, and using Wilcoxon Test for the parameters of S1_A6 and S1_A7; (*) Statistical significance at p<0.05; (**) Statistical significance at p<0.01.

Figure 6 and 7 show the time taken by the Taiwanese cohort to perform the right and left leg activities of balance test, respectively. Significant differences were found in both tests in the comparison of AD and HC groups (p<0.01 for right leg standing and left leg standing).

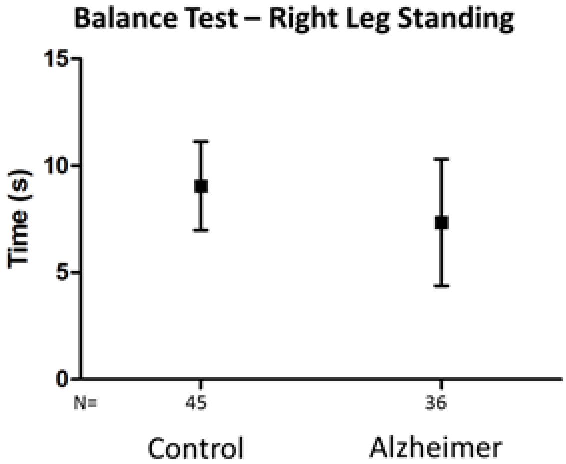

Figure 6. Time taken by Participants to perform the activity “right leg standing” of the balance test in the Taiwanese clinical trial

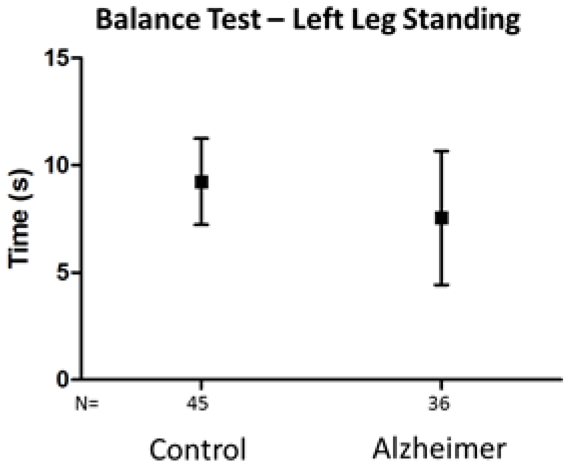

Figure7. Time taken by the Participants to perform the activity “left leg standing” of the balance test in Taiwanese clinical trial

Comparison between France and Taiwan results

Figures 8 and 9 show the mean speed of participants in the TUG test for AD and healthy participants at the French and Taiwanese experimental sites, respectively. In both sites, AD patients presented a significantly lower speed compared with healthy controls in the TUG test (p<0.01).

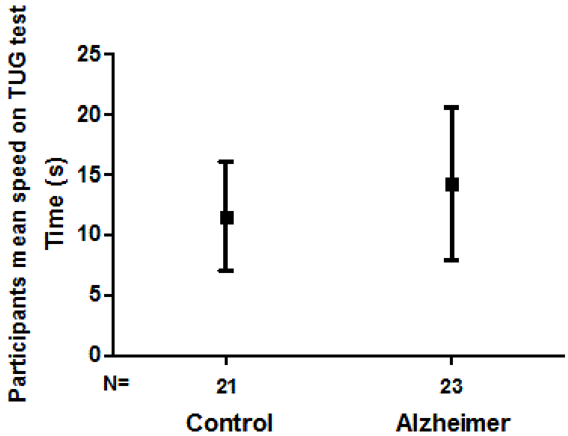

Figure8. Mean speed of French participants in the TUG test

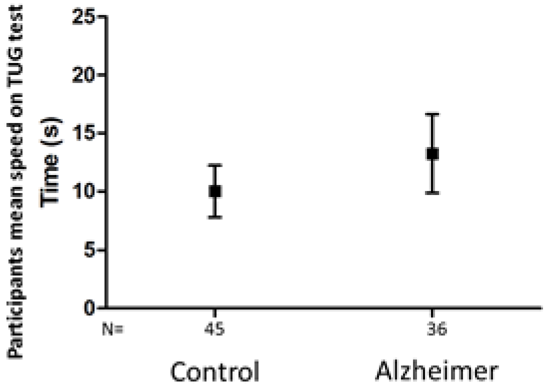

Figure 9. Mean speed of Taiwanese participants in the TUG test

Results for Scenario 02

French experimental site

Tables 10 and 11 present participants performance in Scenario 02 at the French experimental site. Table 10 shows global results according to activity parameters: duration spent inside the room to perform the Scenario 02 (seconds) and organizational errors in activity ordering. Activity ordering errors are presented as the number of participants who at least once omitted, repeated, or changed the expected temporal order of activities.

Table 10. Global performance of the French participants for Scenario 02

Activity	HC	AD	*p-value*
- Total time spent in the room (s)	454±160.4	715±352	0.060
Number of Participants presenting errors about:			
- Activity omission (n, %)	0 (0%)	2 (12.5%)	0.508
- Activity repetition (n,%)	0 (0%)	6 (37.5%)	0.053

- Activity order (n, %)	0 (0%)	4 (25%)	0.106
- At least one error at activities organization (n, %)	0 (0%)	8 (50%¨)	0.008 (**)

P-values for continuous variables were computed using Wilcoxon test; p-values for categorical variables (2 modalities) were computed using Fisher's exact test; (*) Statistical significance at p<0.05; (**) Statistical significance at p<0.01.

Table 11 shows the participants' performance for each activity in terms of speed (seconds), omission, and repetition parameters. The speed term was used instead of activity time duration to imply that lower values of this attribute highlight the ability of a participant at performing the activity faster. AD participants spent more time performing activities that involve sorting or classifying objects (A6 and A7), and they had difficulty to manage the time of reading activity (A1) compared to HC participants.

Table 11. French participants performance for each activity of Scenario 02

Activity	HC	AD	*p-value*
S2_A1			
- Speed (s)	138±79.6	88±215.2	0.001 (**)
- Omitted, N(%)	0 (0%)	0 (0%)	X
-Repeated, N(%)	0 (0%)	2 (12.5%)	0.508
S2_A2			
- Speed (s)	4±3.8	8±13.4	0.660
- Omitted, N(%)	0 (0%)	0 (0%)	X
-Repeated, N(%)	0 (0%)	2 (12.5%)	0.508
S2_A3			
- Speed (s)	25±12.3	28±20.3	0.979
- Omitted, N(%)	0 (0%)	0 (0%)	X
-Repeated, N(%)	0 (0%)	2 (12.5%)	0.508
S2_A4			
- Speed (s)	9±4.4	11±7.2	0.856
- Omitted, N(%)	0 (0%)	0 (0%)	X
-Repeated, N(%)	0 (0%)	3 (18.75%)	0.262
S2_A5			
- Speed (s)	32±24.3	57±57.9	0.165
- Omitted, N(%)	0 (0%)	0 (0%)	X
-Repeated, N(%)	0 (0%)	2 (12.5%)	0.508
S2_A6			
- Speed (s)	78±30.9	143±176	0.216
- Omitted, N(%)	0 (0%)	1 (6.25%)	1.00
-Repeated, N(%)	0 (0%)	3 (18.75%)	0.262
S2_A7			
- Speed (s)	49±21.3	80±48.5	0.129
- Omitted, N(%)	0 (0%)	1 (6.25%)	1.00
-Repeated, N(%)	0 (0%)	0 (0%)	x

P-values for continuous variables were computed using Wilcoxon test; p-values for categorical variables (2 modalities) were computed using Fisher's exact test; (*) Statistical significance at p<0.05; (**) Statistical significance at p<0.01.

Tables 12 and 13 present examples of an AD patient and a HC participant performance in Scenario 02 activities in the French experimental site. In this example the AD participant forgot to perform 3 activities, and performed 2 activities in the wrong order. Comparatively, HC participant performed the activities in the correct order, only omitting one.

Table 12. French AD participant's performance for Scenario 02

Activity	Right Order	Order Error	Omission	Duration (mm:ss)
S2_A1	OK			2:20
S2_A2	OK			0:28
S2_A3			X	
S2_A4			X	
S2_A5		X		0:31
S2_A6		X		1:06
S2_A7			X	

Table 13. French HC participant's performance for Scenario 02

Activity	Right Order	Order Error	Omission	Duration (mm:ss)
S2_A1	OK			01:45
S2_A2	OK			00:16
S2_A3			X	
S2_A4	OK			00:05
S2_A5	OK			00:25
S2_A6	OK			00:55
S2_A7	OK			00:19

Taiwanese experimental site

Tables 14 and 15 show the mean and standard deviation of the speed of participants' activities and their number of errors at performing the activities proposed in the given order (number of activities skipped or performed in an temporal order different from the expected), respectively. Statistical differences were found in the comparison between AD and HC groups (p<0.01, **; p<0.05, *). Activities S2_A4 (water the plant) and S2_A7c ("ABCD" folder) are significant differences between AD and HC for both activity parameters analyzed (speed and frequency).

Table 14. Mean and standard deviation of participants speed in activities of Scenario 02

	Speed (seconds)		
Act.	**A1**	**A2 ***	**A3 ****
AD	129.8±57.8	41.4±21.0	39.7±22.5
HC	121.1±49.2	23.8±12.1	21.7±6.9
Act.	**A4 ****	**A5**	**A6**
AD	52.3±28.7	36.4±24.4	98.8±35.5
HC	25.3±10.4	23.0±11.7	69.5±21.0
Act.	**A7a ***	**A7b ***	**A7c ****
AD	19.4±21.2	78.3±37.9	87.0±46.3
HC	9.4±7.4	50.4±21.0	50.8±19.7
Act.	**A8 ***		
AD	48.1±35.1		
HC	23.2±10.9		

Table 15. Mean and standard deviation of participants' number of errors in the order of activities for Scenario 02

	Errors		
Act	**A1**	**A2**	**A3**
AD	0.20±0.41	0.08±0.28	0.08±0.28
HC	0.26±0.44	0.03±0.18	0±0
Act	**A4 ***	**A5 ***	**A6**
AD	0.23±0.43	0.26±0.45	0.19±0.40
HC	0.03±0.18	0.03±0.18	0.03±0.18
Act	**A7a**	**A7b ***	**A7c ***
AD	0±0	0.13±0.34	0.26±0.44
HC	0±0	0.04±0.18	0±0
Act	**A8**		
AD	0.13 ±0.33		
HC	0±0		

Results for Scenario 04

Table 16 shows participants performance for single and dual tasks of Scenario 04. AD subjects needed to spend more time and perform more steps than did the healthy controls to complete both 40m walking tests. Furthermore, AD patients presented a significant shorter stride length and slower stride speed, especially during dual task in the 40m test. In addition, the gait profiles of the AD patients showed lower stride cadence and lower stride frequency compared with those of the healthy controls, but neither phenomena were significant in single and dual tasks.

Table 16. Performance of participants for single and dual task of Scenario 04

Tasks	**Single**		**Dual**	
Participants	AD	HC	AD	HC
Times**	34.24±5.24	28.40±3.45	64.03±30.77	37.74±7.58
No. of Stride**	32.25±3.36	28.18±2.79	37.81±7.22	28.76±2.49
Stride Cadence (stride/min)	57.01±4.65	59.87±4.79	39.80±11.34	47.15±8.33
Stride Length (m) **	1.25±0.12	1.43±0.14	1.09±0.20	1.38±0.11
Stride Frequency (Hz)	0.95±0.08	1.00±0.10	0.75±0.15	0.83±0.11
Stride Speed (m/s) **	1.20±0.18	1.44±0.20	0.83±0.26	1.14±0.19

(**: p<0.01)

CONCLUSIONS

Certain similarities are seen between results from the Taiwanese and French sites, although a direct comparison of the results of both sites is not possible due to differences in participant population inclusion criteria. Alzheimer's patients can be characterized by several criteria according to the clinical protocol scenarios designed in SWEET-HOME project. AD participants presented a lower balance and a shorter gait length frequency, as well as an irregular gait cycle. Similar findings were also found by Gillain *et al.*[2] who pointed out lower gait speed and lower stride length of AD patients when compared to health controls, in single and in dual tasks (gait speed, stride length, stride cycle frequency, and stride regularity).

Alzheimer's patients have also omitted activities and changed their temporal order indicating a decline in IADLs performance (Scenario 02). Statistically significant differences among AD and HC participants in activity like "watering the plant" could be an indicator of AD participants' difficulty at performing unusual activities.

The proposed automatic sensor monitoring system (ASM and stride detection) provided activity values similar to the ones calculated from events annotated by a human assessor. Although their absolute values differ, they follow the same tendency, and the statistical differences found among AD and HC groups are preserved (Table 8). These findings highlight the use of the proposed approach as a support platform for clinicians to objectively measure AD patients' performance in IADLs and gait analysis. Among the advantages of the ASM system are the stability of its results over time (as it does not suffer from emotional state conditions or biases like stress and fatigue), and its quantitative measurement of patient performance.

FUTURE WORK

Next developments will focus upon automating the detection of activities in the semi-guided and free scenarios of the clinical protocol using the quantitative measurements as evidence for the automated objective assessment of older people frailty. This extended ASM version will be evaluated at differentiating Alzheimer's patients at mild to moderate stages from healthy control participants (comparison between AD/MCI and MCI/Control). A multiple sensor data fusion approach will be also studied to enrich patient activity description, and complement patients motor and cognitive ability monitoring.

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