Research and Work teams

The research team is a **multidisciplinary group** specialized in significant parts of this project: *Iván González* [IGD] and *Jesús Fontecha* [JFD] are PhD on Computer Science. Both IPs have worked together in previous projects and research works. The rest of members in the research team have also previous experience in research projects (national and international) and have collaborated among them. The whole research team is composed by:

1. [IGD][IP1] **Iván González Díaz, PhD** on Computer Science. Lecturer (Prof. Contratado Doctor). Expert on quantitative gait analysis and sensorized wearables.
2. [JFD][IP2] **Jesús Fontecha Diezma, PhD** on Computer Science. Professor (Titular de Universidad). Expert on smart health, mHealth, and ambient assisted living.
3. [JBR] **José Bravo Rodríguez, PhD** on Industrial Engineering. Full Professor. Lead of the MAmI research group and expert on ambient intelligence applied to health.
4. [RHL] **Ramón Hervás Lucas, PhD** on Computer Science. Full Professor. Expert on interactive applications and assistive technology for health.
5. [BGM] **Beatriz García Martínez, PhD** on Computer Science. Lecturer (Ayudante Doctor, acreditada Prof. Contratado Doctor). Expert on affective computing and EEG signal processing and analysis.
6. [TMP] **Tania Mondéjar Palomares, PhD** on Psychology. Lecturer (Ayudante Doctor). Expert on assistive technology applied to neuropsychology.
7. [JNO] **Francisco Javier Navarro, PhD** on Medicine, professional Geriatrician at SESCAM and adjunct professor at UCLM Medicine Faculty. Expert on frailty and dementia.
8. [ISC] **Inocente Sánchez Ciudad**, Professor and expert on signal processing.

The group of researchers involved in the working plan (work team) includes stable and active members of the MAmI group [EJR, LCG, APG, APV, DCP] with contractual relationship with the university. The rest are renowned international researchers in areas related to the project:

1. [EJR] **Esperanza Johnson, PhD** on Computer Science; Research Lab. Technician (PTA) at WeCareLab. Specialized on Cognitive and Affective Computing, and end-user evaluations.
2. [LCG] **Luis Cabañero Gómez, PhD** con Computer Science. Post-doctoral contract associated with FPI-JCCM grant. Expert on healthdata analytics, artificial intelligence and biomedical signal processing.
3. [APG] **Alberto Pinto Gil, PhD** on Science of Physical Activity and Sports, he is adjunct professor at UCLM and secondary school teacher. Expert on topics related with physical activity and health.
4. [APV] **Alejandro Pérez Vereda**, Last-year PhD candidate (FPI) with research topics on personal data management applied to health.
5. [DCP] **David Carneros Prado**, PhD candidate (FPI-PlanPropioUCLM) with research topics on machine learning, data science, cloud computing and smart health.
6. [VIV] **Vladimir Villarreal PhD**. (UTP, Panamá): Full-Time professor. Awarded Researcher of the year 2016. PhD obtained in the UCLM. Expert on mobile-based monitoring for health. Director of GITSE research group.
7. [ChN] **Chris Nugent, PhD** (Ulster University, UK): Head of the School of Computing and Professor of Biomedical Engineering. From 2015-2017 Chris was the Director of the Computer Science Research Institute. He was awarded the Senior Distinguished Research Fellowship from Ulster University. His research includes the topics of mobile based reminding solutions, activity recognition and behavior modeling, and technology adoption modelling.
8. [JFav] **Jesús Favela, PhD** (CICESE, Mexico): Dr. Jesús Favela is one of the most prestigious researchers in Mexico. He developed his PhD at MIT, USA and he is an expert on human-computer interaction and physical activity recognition.
9. [IHL] **Irvin Hussein López, PhD** (CICESE, Mexico): Dr. Hussein is specialized in activity tracking and signal analysis. He developed his doctoral dissertation at INAOE research center.

On the other hand, [BGM] and [TMP] will take on leadership tasks, as well as relevant participation in other tasks ([EJR], [BGM] and [TMP]) **promoting women integration** in the work plan according to their valuable proven skills.

Additionally, **we will also need to hire a Computer Engineer** ([Hi.1]) with some background in research activities. His/her main work will be the development of software services and modules for data acquisition and integration according to the designed framework. In the second half of the project, it will be necessary **to hire a person specialized in artificial intelligence and data science** ([Hi.2]), with a master's degree recommended, who will help refine the procedures of the AI platform for MCI patterns detection, as well as the support in trials/evaluations. To sum up, the total number of months with a necessity of hired technicians is 34. As noted earlier, we will positively value the integration of women at this point in order to promote gender balance in the project team.

Work Packages and Project shedule
In line with the phases that make up the project (see Section 3.2), the following 4 Work Packages (WPs). Have been defined. Each WP is guided by a specific methodology (Section 3.2). In each phase, there can be tasks from different WPs (described in detail in Figure 2).

<u>Work Package 0 [WP0]: Coordination, Management, Dissemination and Ethics</u>
Person in charge: Iván González Díaz [IGD] and Jesús Fontecha Diezma [JFD]
Duration: Months 1 - 36
Description: Promote the dynamic and effective interaction of the different project participants, as well as **ensuring that the project's objectives defined in the methodology are carried out**. Project's results will be disseminated according to the **dissemination plan**. Finally, the ethical and privacy implications are monitored and ensured.
Identified deliverables: Management documentation [E01], Requirement's report [E02], Dissemination results summary [E03], Security &privacy guidelines [E04], Transference plan [E05], Audit report [E06]

<table>
<tr><th colspan="3">Task 0.1: Requirements and analysis</th></tr>
<tr><td>Duration in months (mo): 1-3</td><td>In charge: IGD</td><td>Participants: Full Research Team, Experts</td></tr>
<tr><td colspan="3">Task description: To determine the overall management of the project, ranging from the global requirement analysis, trials definition and protocols to acquire data and procedures for system minimization. This task follows the user-centered perspective and involves multidisciplinary external experts and OPEs (Observer-Promoter Entities). The inclusion/exclusion criteria for participant recruitment will be defined with the support of OPEs related with end-users. The contingency plan will be detailed in this task.</td></tr>
<tr><th colspan="3">Task 0.2: Project Management and Ethics</th></tr>
<tr><td>Duration (mo.): 4-36</td><td>In charge: IGD, JFD</td><td>Participants: Full Research Team</td></tr>
<tr><td colspan="3">Task description: Project coordination, including compliance with ethical aspects and principles of Responsible Research and Innovation (RRI). The experiments designed in tasks T3.1 and T4.1 will be proposed to be validated by ethical committee. The task also includes the holding of monthly meetings to follow up on tasks and quarterly meetings to review the progress.</td></tr>
<tr><th colspan="3">Task 0.3: Dissemination</th></tr>
<tr><td>Duration (mo.): 10-36</td><td>In charge: IGD, JFD</td><td>Participants: All</td></tr>
<tr><td colspan="3">Task description: The advances of the project will be disseminated following the dissemination plan (see Section 4.4). In Figure 2, main expected results are indicated from which dissemination items will be released. This task involves the development of a transference plan (Section 4.5).</td></tr>
</table>

<u>Work Package 1 [WP1]: Development, deployment and testing of the multi-modal sensory data acquisition framework</u>
Person in charge: Jesús Fontecha Diezma [JFD]
Duration: Months 4 - 10
Description: This work package involves the development of a comprehensive multi-modal sensory data acquisition framework capable of **synchronizing and gathering heterogeneous data** from **multiple sensing sources** (body-worn sensors, ambient sensing systems and the smartphone itself) in a unobtrusive manner. The sensory data acquisition framework must deal with different levels of abstraction, entropy and data acquisition frequency to **dynamically adapt itself** to different number of sensors and complexity. **Identified deliverables**: Sensorization ontology for human motion monitoring [E11], Multi-modal sensory data acquisition framework [E12], Highly replicable insoles prototype [E13].

Task 1.1: Device Authentication and Registration service		
Duration (mo.): 4-6	**In charge**: JFD	**Participants**: JBR, ISC, BGM, LCG, Hi.1
Task description: At a high level of abstraction the data acquisition framework is made up of several modules and services. The Device Authentication and Registration service is used to connect authorized devices to the sensing infrastructure. Each data source device has its own specifications, in terms of the data stream generated, which are propagated during the device registration process. These specifications are then used by the Data Curation Layer (**T2.1**) as part of the AI platform (**WP2**) to produce generic sensory data streams for further processing.		
Task 1.2: Multi-Protocol Wireless Communication module		
Duration (mo.): 4-6	**In charge**: BGM	**Participants**: IGD, JBR, ISC, LCG, Hi.1
Task description: The data acquisition framework must support heterogeneous wireless communications, that includes devices/systems with embedded transceivers to connect through Personal and Wireless Local Area Networks. In this sense, a **BLE Gateway** and a **MQTT Broker** are required to establish bi-directional data transfers between different wireless devices, ambient systems and the acquisition framework.		
Task 1.3: Sensory Device Synchronizer service		
Duration (mo.): 4-6	**In charge**: IGD	**Participants**: JBR, ISC, BGM, RHL, Hi.1
Task description: The key in the multi-modal data acquisition is the **association of accumulated data with their origination time**. All connected data sources subsist independently along with independent clocks and different acquisition frequencies; thus, a **synchonizer service** with a **logical/master clock** is required for identifying the data origination at the same time from multiple sensory devices and for correcting time drifts.		
Task 1.4: Non-curated Sensor Data storage		
Duration (mo.): 7-8	**In charge**: JFD	**Participants:** IGD, BGM, DCP, ChN, JFav
Task description: Individual data from each source device is **temporally stored in the Sensor Data Storage** (Data Accumulation) and it is accessible by the **Device Synchronizer** service (T1.3), through the **Data Access Interface**, to correct/sync timestamps prior to its transfer to the **Data Curation layer** (WP2).		
Task 1.5: Self-developed Wearable Devices Adaptation		
Duration (mo.): 9-10	**In charge**: IGD	**Participants:** JBR, JFD, BGM, JFav, Hi.1
Task description: The prototype of **pressure sensorized insoles** developed in FRASE research project, refined in M4S and which continues to evolve in the current proof-of-concept sSITH project, will be **adapted for use in JUST-MOVE** (see Section 3.5). It means **firmware changes** and in the insoles' hardware to meet the **authentication**, **communication**, and **sync** needs of the sensory data acquisition framework. This wearable, wristbands and the smartphone are potential data acquisition sources to be maintained in the reduced data acquisition infrastructure.		

Work Package 2 [WP2]: Data Processing AI-based platform
Person in charge: Ramón Hervás [RHL]
Duration: Months 11 - 24
Description: The Data Processing AI platform developed in this work package is intended to be a useful tool to identify **early cognitive impairment signs** from the everyday life human motion collected by the multi-modal sensory data acquisition framework (from **WP1**). It is a **multi-layer architecture** that will be hosted on a **cloud server** composed by 5 layers: i) the **Data Curation** layer that produces generic **semi-structured** sensory data streams; ii) the **Short-term Feature Extraction** and iii) **Mid and Long-term Feature Extraction** layers that produce both sets of features, considering short-term and mid and long-term temporal contexts, respectively; iv) the **Information Curation** layer which is the core of the MCI inference and modeling and v) the **Knowledge Shareability, Analytics, and Visualization** layer to facilitate the generation of open/shareable datasets.
Identified deliverables: Data Processing AI-based platform [E21], Knowledge Shareability tool [E22].

Task 2.1: Data Curation layer		
Duration (mo.): 11-21	**In charge**: RHL	**Participants**:JBR, LCG, ChN, IHL, APV, EJR

Task description: This layer oversees labeling and **offline preprocessing** synchronized data streams coming from the registered sensing sources (**T1.1**). These streams are temporally stored by the acquisition framework (**T1.4**) to produce a **semi-structured curated** data stream which is persisted in the **Curated Sensor Data storage**. Semi-structured curated data is the input for the feature extraction layers (**T2.2** and **T2.3**).		
Task 2.2: Short-term Feature Extraction layer		
Duration (mo.): 11-24	**In charge**: RHL, IGD	**Participants**: LCG, DCP, VIV, APV, IHL, Hi.1
Task description: **Semi-structured curated** data from **T2.1** is mapped to **ontological short-term features** that represents the short-term temporal context of human motion as hierarchical resources. From the typology of each semi-structured curated data, according to the specifications of data sources registered in **T1.1**, an ontological representation that hierarchically models specifications and resources is applied. The **ontology determines short-term features that can be extracted, in short time frames**, considering the nature of each current curated data in a kind of automatic and adaptative feature extraction process. Note, that not all the curated data can provide relevant features in the short term, e.g., stride interval variability is not often assessed in short time periods in the relevant literature about MCI and its relation to gait.		
Task 2.3: Mid and Long-term Feature Extraction layer		
Duration (mo.): 11-24	**In charge**: RHL	**Participants**: LCG, DCP, IGD, APV, IHL, Hi.1
Task description: Similar to **T2.2**, this task automatically generates medium and long-term ontological features that represent the mid and long-term temporal context of human motion.		
Task 2.4: Information Curation layer. Inference and modeling of the MCI context		
Duration (mo.): 16-24	**In charge**: JBR	**Participants:** ISC, JFD, LCG, DCP, TMP, Hi.1, Hi.2
Task description: The ontological method to automatically extract features of temporal context of human movement from **tasks T2.2 and T2.3** provides the **input** for the **Information Curation** layer. This task is the **core for the MCI context modeling** and **inference subsystem**, and it consists of a **Machine Learning (ML) stack** that allows to build, train and deploy sets of ML ensemble models and test their performance. Lab and field trials (**WP3**) and evaluations in real life scenarios (everyday trials – **WP4**) will use the MCI context modeling and inference subsystem from the Information Curation layer.		
Task 2.5: Knowledge Shareability, Analytics and Visualization layer		
Duration (mo.): 18-21	**In charge**: JFD	**Participants:** IGD, LCG, APV, ISC, Hi.1, Hi.2
Task description: It aims to provide a supplementary tool to promote **shareability** of remarkable curated data for knowledge generation, analytics, and visualization. The functionality of this software layer will allow the generation of **open datasets** to promote the reproducibility of experiments and their subsequent **dissemination**. These datasets will be placed in available open repositories (see Section 4.6 **Summary´s management plan of the planned data**).		

Work Package 3 [WP3]: Lab and controlled environments field trials
Person in charge: Francisco Javier Navarro [JNO], Tania Mondéjar [TMP]
Duration: Months 22 - 27
Description: **Explicit lab trials** in the *WeCare living lab* (Section 3.6) combined with short-term evaluations in **controlled environments** (**field trials** at home or in nursing homes) are carried out in this work package. The trials are conducted with a selected **focus group** of **adults**. The multi-modal sensory data acquisition framework (**WP1**) and the data processing AI-based platform (**WP2**) are used with a twofold goal: i) the **gradual reduction of the sensor infrastructure**, managing data acquisition uncertainty; and ii) the system preparation for continuous everyday trials through a non-intrusive and minimal sensor infrastructure (**WP4**).
Identified deliverables: Protocol and sample selection criteria for lab and field trials [E31], Datasets with short-term movement features collected from lab and field trials [E32], Stack of Machine Learning trained models for MCI detection from short-term motion features [E33].

Task 3.1: Design of Lab and Field Trials		
Duration (mo.): 22-23	**In charge**: JFD, JNO	**Participants**: TMP, JBR, EJR, VIV, APG

Task description: This task involves the definition of **protocols, sample selection** and **preparation** of both experiments, for lab (**T3.2**) and controlled environment field trials (**T3.3**), according to the criteria and suggestions of the **research ethics committee**. In this sense, **cognitive tests**, such as the Mini-Mental State Examination (MMSE), together with the **geriatric specialist's criteria** will be used to determine the degree of mild cognitive impairment.		
Task 3.2: Lab Trials Execution		
Duration (mo.): 24-26	**In charge**: JNO	**Participants**: EJR, TMP, APG, APV, Hi.2
Task description: Explicit lab trials will enable quantitative analysis of **gait, balance, and limb movements** with high accuracy through an infrastructure of **body-worn sensors** (Wireless EMG, inertial and plantar pressure monitoring systems) as well as **ambient sensing**, such as 3D motion capture cameras. From this kind of **comprehensive infrastructure** (only possible in clinical settings) **short-term features** (**T2.2**) can be extracted and used by the Information Curation layer (**T2.4**) to train the machine learning stack and test the performance in **MCI context modelling**.		
Task 3.3: Field Trials Execution		
Duration (mo.): 25-27	**In charge**: TMP	**Participants**: EJR, RHL, APV, APG, Hi.2
Task description: Field trials in controlled environments also carry out **assessment of human movement**. However, **ambient sensing systems are dispensed** in this task and the infrastructure of **body-worn sensors is reduced** to the simplest and least intrusive devices (sensor embedded in the smartphone, inertial bracelets, and inertial/pressure insoles to monitor plantar pressure patterns and limb movements), all of them with BLE communication with the user' smartphone. Field trials also focus on **short-term temporal context of human movement** to **model MCI detection**, as in T3.2, but infrastructure is minimal here and field trials are conducted outside the clinical settings through **explicit controlled trials at home** or in **nursing homes** for the elderly. This task is the prelude for the **everyday** trials in **WP4**.		
Task 3.4: Refinement Process based on the Results of Lab and Field Trials		
Duration (mo.): 24-28	**In charge**: RHL	**Participants:** JNO, TMP, JFD, IGD, ISC, Hi.2
Task description: This task mainly involves refinement of **software artifacts** (**T2.1, T2.2**. and **T2.3**) and adjustments in the **ML stack** (**T2.4**) and training algorithms from the **Data Processing AI-based platform (WP2)**. These modifications and refinements are made based on the **feedback and results** obtained in the **lab and field trials** (T3.2 and T3.3), in order to achieve a **gradual reduction of the sensor-based infrastructure** managing uncertainty in the data input (without losing performance in MCI context modeling).		

Work Package 4 [WP4]: Everyday data acquisition trials.

Person in charge: Iván González [IGD]
Duration: Months 28 - 33
Description: This work package consists of the development of **mid-term and long-term evaluations** over a **6-month** period divided into **monthly trials**. A larger sample of selected end-users than in **WP3** will take part in the **everyday trials**. Participants will continuously **wear** a **minimal** set of **non-intrusive body sensors**, according to the refinement process performed in T3.4 while going about their daily lives. Everyday trials will allow modeling the mid and long-term temporal context of human movement (in addition to the short-term).
Identified deliverables: Protocol and sample selection criteria for everyday trials [E41], Datasets of short, mid and long-term human movement features collected from everyday trials [E42], Machine Learning trained models for MCI detection from everyday motion data [E43].

Task 4.1: Design of Everyday Trials		
Duration (mo.): 28-29	**In charge**: JFD	**Participants**: TMP, JNO, APG, EJR, RHL
Task description: This task involves the definition of **protocols, sample selection** and **preparation** of everyday trials (**T4.2**) according to the criteria and suggestions of the **research ethics committee** and **geriatric experts**. While some of the participants may have been involved in previous lab and field trials (T3.2 and T.3.3), **everyday trials** will incorporate a larger sample of older adults. Different **cognitive tests** will be used to determine their cognitive baseline state.		
Task 4.2: Everyday Trials Execution		
Duration (mo.): 30-32	**In charge**: JNO	**Participants**: TMP, EJR, BGM, APG, Hi.2

Task description: Everyday trials focus on adding **mid-term** and **long-term temporal contexts of human movement** (beyond short-term features) to **model MCI detection** through the **minimal body-worn sensor infrastructure** (result of the refinement processes of packages **WP3** and **WP4**). These mid and long-term temporal contexts are crucial in MCI modeling because they allow to incorporate human movement related **features whose variability is more relevant over large time** frames rather than short-time frames. Relevant features of human movement are gathered **continuously** while participants going about their daily lives.		
Task 4.3: Refinement Process based on the Results of Everyday Trials		
Duration (mo.): 31-35	**In charge**: IGD, JFD	**Participants**: JNO, TMP, RHL, ISC, Hi.2
Task description: This task involves new refinement of **software artifacts** (**T2.1**, **T2.2** and **T2.3**) and adjustments in the **ML stack (T2.4)** and training algorithms from the **Data Processing AI-based platform (WP2)** after getting feedback and results from each monthly everyday trial (**T4.2**). Thus, this task **runs in parallel with the everyday trials**.		

Figure 2 shows the complete time schedule beginning in September 2023.

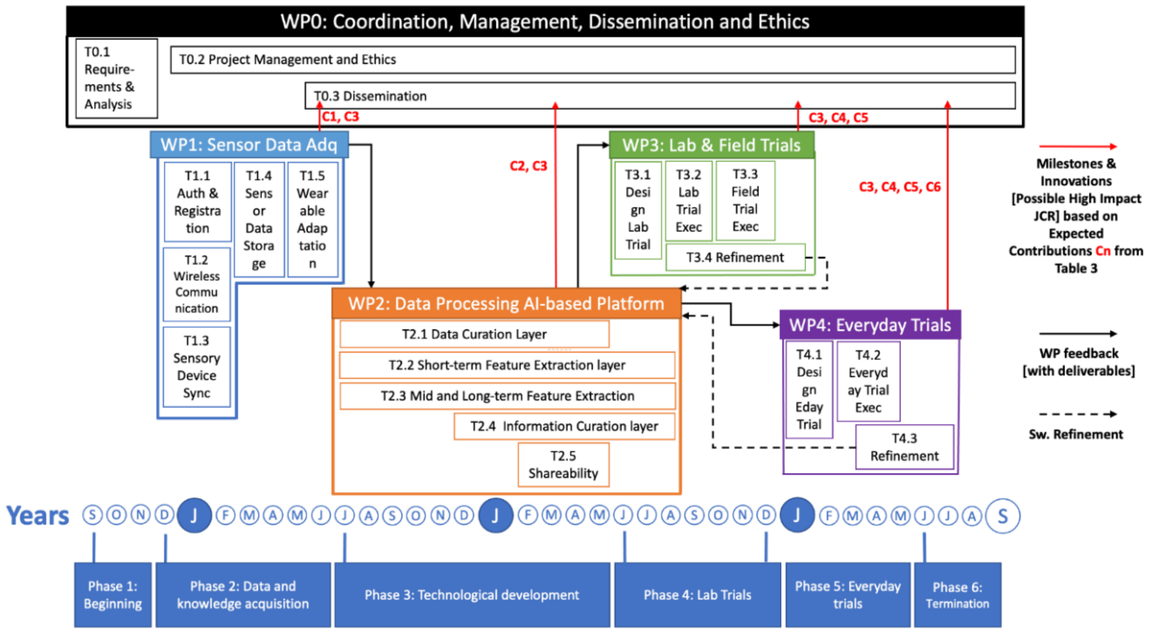

Figure 2. Time schedule with phases and plan, including: work packages, relationships and expected results (see Section 4.3)

3.4. *Identification of critical points and contingency plan*

The risks associated with this project have initially been studied and will need supervision during the whole project's period. The research team will always seek to identify potential issues early before they cause a problem. Anyhow, the main responsibility of risk monitoring and consequent actions are on both IPs. During the Task 0.1, the contingency plan will be checked and deeply studied starting from the initial plan of significant risks (see Table 2, also considering the most critical phases detailed in Section 3.2):

Severity	Risk description	Objectives and WP(s) concerned	Contingency plan	Risk mitigation options*
Med.	Technical issues from data sources for motion acquisition	SO1 / WP1	Review the data acquisition & synchronization process. Consider alternative sensing sources or new ways for the affected data sources without hindering other processes	Decrease / Avoid
High	End-users recruitment difficulties	SO2, SO3 / WP3, WP4	Looking for alternative potential participants among our EPOs and centres or associations with which we collaborate in other works	Decrease / Avoid