eGlasses

The specification of overall requirements

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Consisting of:

Coordinator:

Gdansk University of Technology, FETI, DBME	Poland

Partners:

University of Applied Sciences Upper Austria, MIL	Austria
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Ver.	Date	Changes	Author
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Table of Contents

The eGlasses consortium receives the funding support of NCBiR, FWF, SNSF, ANR, and FNR in the framework of the ERA-NET CHIST-ERA II.

1 Introduction

The overall requirement of the eGlasses project is to provide an open hardware and software augmented reality platform that can be used by third parties after the project. The hardware should support not only existing augmented reality interaction paradigms but also perceptual computing approaches. By this we mean the ability for the system to support human-like perceptual awareness of the surrounding environment and for the user to be presented with a range of interaction options. These approaches can extend from interacting with real world objects, such as a lamp (for example looking at it turns it on) through to being able to correctly interpret data such as heart rate and body temperature of a patient. The system must therefore be able to fuse data from a variety of sensors in real time. In addition to supporting user interaction it must also support the analysis of user behaviour such that effective end-user studies can be carried out.

The purpose of this document is to review the requirements of the platform in terms of human factors issues that to be addressed, provide an update on the state of the art in augmented reality requirements and to provide an early technical specification. Addressing these issues will ensure that the platform can deliver its full potential when actually operated by the end-users. Indeed, a poorly designed system will not only reduce utility and acceptance of the platform but also induce discomfort and frustration. The document keeps the requirements at a general level as it does not support specific use-case implementations. Instead this document provides a list of general specifications and requirements that must be addressed in order for the eGlasses platform to be a success.

In the section two we describe the fundamental stakeholders which are assumed to take part in the design process of the platform over the project's life. In the section three we review general Human-Machine Interaction (HMI) design requirements. We take into account the physical level (interaction between device's hardware and user's body), the cognitive level (ability of human to process the additional source of information), the interaction level (structuration of user/system interactions) and the social level (utility and acceptability). In the section four, we present a summary of the generic requirements for each specific hardware module.

2 Fundamental stakeholders

One of the main goals of the project is to create a platform for experimental verification of methods in the field of human-system interaction. Therefore, the most important stakeholders are researchers. This contracts where proposed new methods of interaction are often focused on end users. It is acknowledged that end users (e.g. a healthcare professional, disabled person, etc.) are important categories of stakeholders. However, within the eGlasses project the tests in order to verify the system will be undertaken be researchers. As a result there is a need to balance both the needs of end-users and researchers. These two groups along with additional stakeholder are identified (See also Table 1).

In the context of electronic eyewear there are two potential groups of stakeholders including the wearer (user) and people who are observed by the wearer. This requires a consideration of privacy aspects of the usage of the eGlasses platform, especially in public locations where they may not be able to interact with the system themselves.

Additionally, a set of organizations is also included to the list of stakeholders, including: CHIST-ERA Consortium, NCBiR, FWF, SNSF, ANR, and FNR.

Tab. 1. List of fundamental stakeholders

#	Stakeholders	Role
1	Researchers	Experimental verification of proposed methods
2	End users	Testers and potential users of the electronic eye-wear and methods
3	Observed People	Observed subject, potential source of information (including medical data)
4	Founding agencies	CHIST-ERA Consortium, NCBiR, FWF, SNSF, ANR, and FNR

3 General Design Requirements

3.1 Physical level

The physical requirements of the project are concerned with the direct interaction between the human body and the device.

3.1.1 Display readability

Augmented-reality glasses are primarily meant to provide visual information. Hence, readability should be guarantee both for iconic or textual information. Readability is a product of the display characteristics (e.g. size, position in the field of view, opacity, luminescence and contrast ratio).

Displayed text should be easy to read and it depends on various parameters, including not only the family of typeface and the size, but also the colours and foreground/background contrast. Gabbard and Swan (2007) found that text legibility is improved when drawing algorithms take into account the contrast ratio between the text and drawing style and contrast between drawing style and the background.

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Placement of multiple widgets should also not interfere between themselves: although it was demonstrated that drawing speed is a very important parameter even if placement is not ideal (Azuma and Furmanski, 2003).

3.1.2 Fatigue and eye strain

Augmented-reality systems are tools to which the user should adapt him/her-self (the ideal being the least adaptation required) both physically and mentally. Where significant amounts of adaption are required users may end up suffering from fatigue. Fatigue involves both negative physical feelings and decrease in performance (Ellis, Breant, Manges, Jacoby, & Adelstein , 1997). In the context of augmented reality systems, fatigue can refer to muscle[1] fatigue (while wearing/holding physical system, or performing gestural interaction) and cognitive/mental fatigue (prolonged period of mental activity, see also Marcora, Staiano and Manning, 2009).

3.1.3 Sensory overload

In the field of sensory substitution, the concept of sensory overload has been reported (Bach-y-Rita and Kercel, 2003) as the over-stimulation of the sensory system on a particular modality. The authors suggest the potential effect of poor information content or too artificially encoded information would trigger this phenomenon rather than the mere quantity of information being transferred to the sensory channel. In the particular-case of augmented-reality devices, sensory overload may for example happens following a long exposition to low quality but high intensity graphics?

3.1.4 Adaptation and learning

The user needs to adapt to the specificity of the system and once this is done, the user should be able to switch back to normal behaviour without being too impacted (i.e., absence of post-effect). For example, Biocca and Rolland (1998) reported that the mapping between the position of the camera and hand reaching actions could be affected after the use of the system.

3.1.5 Thematic bibliography

Azuma, R., & Furmanski, C. (2003, October). Evaluating label placement for augmented reality view management. In Proceedings of the 2nd IEEE/ACM international Symposium on Mixed and Augmented Reality (p. 66). IEEE Computer Society.

[1] http://www.nlm.nih.gov/cgi/mesh/2011/MB_cgi?mode=&term=Muscle+Fatigue

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Bach-y-Rita, P., & W Kercel, S. (2003). Sensory substitution and the human–machine interface. Trends in cognitive sciences, 7(12), 541-546.

Biocca, F. A., & Rolland, J. P. (1998). Virtual eyes can rearrange your body: Adaptation to visual displacement in see-through, head-mounted displays. Presence: Teleoperators and Virtual Environments, 7(3), 262-277.

Gabbard, J. L., & Swan, J. E. (2007). Usability engineering for augmented reality: employing user-based studies to inform design. IEEE transactions on visualization and computer graphics, 14(3), 513–25. doi:10.1109/TVCG.2008.24

Ellis, S. R., Breant, F., Manges, B., Jacoby, R., & Adelstein, B. D. (1997, March). Factors influencing operator interaction with virtual objects viewed via head-mounted see-through displays: viewing conditions and rendering latency. In Virtual Reality Annual International Symposium, 1997., IEEE 1997 (pp. 138-145). IEEE.

Marcora, S. M., Staiano, W., & Manning, V. (2009). Mental fatigue impairs physical performance in humans. Journal of Applied Physiology, 106(3), 857-864.

3.2 Cognitive level

The cognitive level consists of the processes related to information processing and merging of information into user's mental representation of their own activity and environment.

3.2.1 Registration

This involves the relationship between the augmented objects and the real environments such that the augmentations appear "part of" the actual scene. The quality of the process is critical as a poor registration quality can prevent the correct understanding of and interaction with the given augmentation. Two registrations errors exist (see also Azuma and Baillot, 2001):

- Information not delivered at the right location
- Information not delivered at the right time (Latency)

These problems may be partially overcome through the use of improved algorithms to detect and correctly place the location of augmentations. These could include computer vision approaches, sensor data or improved contextual awareness of the underlying environment.

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3.2.2 Data density / information overload

Azuma and Baillot (2001) mentioned the information density problem. Information density refers to the quantity of information in a specific node of the user-interface (and its area). It is clear that high quantity of information will make the display cluttered, unreadable and will overload the user. This phenomenon is known as information overload and refers to an information quantity overwhelming human cognitive capacity. In such cases information on delivered by the system:

- could not possibly be processed entirely in a reasonable amount of time
- requires more effort for the user to search for
- may distract the user by consuming attention resources on non-critical information

Information density may change according to the task at hand and the context. Some prototypes have been developed (e.g., Bell, Feiner and Höllerer, 2001; Julier et al., 2000) without having been evaluated with user-studies.

3.2.3 Distraction

Distraction can be related to information overload. Distraction is however likely to be linked to a lack of attentional resources or a flawed information scanning strategy. It refers to the capturing of the user's attention by information items that are not relevant to the current task and results in:

- delayed response time
- non-detection of relevant information

3.2.4 Interruption / resuming

Distraction can also be a result of the user’s current task being interrupted. Such interruptions have an impact on the user’s primary task performance (See Cutrell, Czerwinski, and Horvitz, 2001; Gill, Kamath and Gill, 2012) and thus should be avoided or allowed only when this would add value to the user’s current activity.

We should assume that user’s primary task and non-virtual interactions have priority. Hence, while efforts should be made to reduce the risk of interruption it is important that any system is designed to support this in an appropriate way.

In this regard, Google[2] refers to the concept of fire-and-forget, this encourages developers to design interfaces that are minimalist and modular. As a result there is less chance of an application preventing the user from interacting with their next desired aspect of interest.

[2] https://developers.google.com/glass/design/principles

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3.2.5 Thematic bibliography

Bell, B., Feiner, S., & Höllerer, T. (2001, November). View management for virtual and augmented reality. In Proceedings of the 14th annual ACM symposium on User interface software and technology (pp. 101-110). ACM.

Cutrell, E., Czerwinski, M., & Horvitz, E. (2001). Notification, disruption, and memory: Effects of messaging interruptions on memory and performance.

Gill, P. S., Kamath, A., & Gill, T. S. (2012). Distraction: an assessment of smartphone usage in health care work settings. Risk management and healthcare policy, 5, 105.

Julier, S., Lanzagorta, M., Baillot, Y., Rosenblum, L., Feiner, S., Hollerer, T., & Sestito, S. (2000). Information filtering for mobile augmented reality. In Augmented Reality, 2000.(ISAR 2000). Proceedings. IEEE and ACM International Symposium on (pp. 3-11). IEEE.

3.3 Interaction level

Interaction level refers to the design of an application's user-interface and interactions flow. In this regard the project will seek to build on existing good practice for user interface design, while addressing the challenges posed by augmented reality platforms. For example, while Nielsen (1994)[3] provides a good basis for standard GUIs (see below) such guidelines were developed before augmented reality become more widely available. Additionally work on augmented reality games has highlighted a number of factors relating to usability issues such as attention allocation and simplified interaction schemes[4] through to aspects such as sense of presence[5]. While game design is beyond the scope of this project many of the basic concepts remain relevant, furthermore AR game design may help to provide some pointers relating to aspects such as awareness of the surrounding environment and level of engagement/focus of attention on augmentations vs the surrounding environment. In addition to these more abstract concepts we will also draw on the ideas devised for the Google Glass platform such as the use of common interaction patterns and by extending this to also taking into consideration the possibilities afforded by the perceptual computing and open nature of the project.

[3] Nielsen, J. (1994). Heuristic evaluation. In Nielsen, J., and Mack, R.L. (Eds.), Usability Inspection Methods, John Wiley & Sons, New York, NY

[4] Herbst, I & Braun A., et al (2008). TimeWarp: Interactive Time Travel with a Mobile Mixed Reality Game. MobileHCI'08 Proceedings of the 10th International Conference on Human Computer Interaction with Mobile Deices and Services. Pp235-244. ACM.

[5] Blum, L. & Wetzel, R. et al (2012), The Final TimeWarp: Using Form and Content to Support Player Experience and Presence when Designing Location-Aware Mobile Augmented Reality Games. The Proceedings of Designing Interactive Systems Conference 2012, p711-720. ACM.

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3.3.1 Early User Interface Design Considerations

The list below is derived from the work of Jacob Nielsen and identifies a number of core aspects of simple user interface design, while not entirely relevant to augmented reality they provide a starting point of issues to consider and to a large part can be adapted for use within the field of perceptual augmented reality:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

Some aspects for example, helping users to recognise and recover from errors are more problematic when the task end point is not so clearly defined. Also the help and documentation aspects are also challenging in that unlike traditional desktop computer systems it would not be appropriate to provide hundreds of pages of text for people to read within AR glasses, also searching for help information via typing keywords is currently problematic.

3.3.2 Task Flow

In common with Google Glass there is a high risk that users will start a task and not finish it, for example due to a distraction within the real environment but also due to error. In common with Google we propose to follow the idea of allowing people to "drop tasks" without this causing the system to freeze. Instead they will be able to drop the task and start another one if they wish to do so.

Task flow will be designed to support:

1. Continued awareness of the surrounding environment such as to avoid accidents (essentially being context aware)
2. Support ability to end a task without blocking the system

3.3.3 Interaction with Real Environment and People

A major challenge within eGlasses is to allow seamless interaction with the real environment, whether this includes interaction with real objects, locations or other people (both eGlasses and non-eGlasses users).

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When interacting with objects:

1. Model actions available on the object and make them (where possible) available via augmented reality, for example turning a light on or off.
2. Adhere to any privacy models which may be relevant for a particular object, person or location

When interacting with people, for example providing additional information on them:

1. Adhere to privacy requests
2. Allowing easy sharing of information between headsets for example a gesture to send data to another person
3. Allow easy collaboration on common shared artefacts (objects)
4. Recognition of other people

3.3.4 Standardisation of Interaction

As the objective of the project is for the platform to become accessible and usable by non-project members we will seek to develop a set of standard user interface components and interaction patterns that can be tested within the various use cases.

3.3.4.1 Interface Widgets

It is important that interface components are consistent in terms of presentation and interaction, for this we will develop a number of common interface widgets, a provisional list is outlined below:

1. Menus
2. Labels
3. Alerts
4. Status information (e.g.) time, location etc.

The eGlasses platform will standardise where certain interface elements are displayed on the screen e.g. status or alerts. We will also seek to allow mixed modality interaction for example allowing a menu to be activated by voice, gesture, eye position or other (mixed) modalities.

3.3.4.2 Interaction Patterns

It is important to create a set of standardised interaction patterns which fuse the input devices with desired user actions, we will seek to develop a group of such interaction patterns which are applicable across a range of context of uses, for example for privacy issues.

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3.3.4.3 Voice Interaction

As noted earlier microphone input will provide another method of interaction. This will explore using voice interaction for a range of purposes, for example:

- dictating non-command based data, for example the name of a person or location
- proving system commends such as "open picture" etc.

3.3.4.4 Gesture Based Interaction

In common with Google Glass we will initially explore gesture based interaction within the region directly around the eGlasses device. However, as the project progresses we will explore approaches which allow for gestures within a wider area and possibly on other devices and surfaces. One possible area of work includes the use of clothing sensors to detect gestures.

3.4 Social level

While it is possible for the eGlasses platform to be well designed from both a technical and usability perspective, there remains a number of challenges. One major aspect is how to support both social acceptance (e.g. gestures which do not offend people) and the privacy of both eGlasses and non-eglasses users.

3.4.1 Privacy

3.4.1.1 People

Other users of eGlasses and members of the public must be able to indicate their preferred privacy settings. This should be done to allow for users and non-users to set who else can see their information and also what information is presented to them. However, under the medical use case conditions key (life saving) information should be available at all times to authorised medical staff.

eGlasses users can define profiles with information categorised as to their desired degree of privacy, for example basic information such as "name" or "display name" should be available to all other eGlassses users if enabled. Whereas, medical details and information are only available to eGlasses wearers with appropriate authority.

3.4.1.2 Real World Objects

Certain objects may afford interaction (and data viewing/editing) possibilities to a limited set of users, they may also provide levels of user access.

3.4.1.3 Locations

Location-based data may also be available only on a limited basis, with restrictions based on user level. The user must be informed about location data collection and provide his/her consent on this regard.

3.5 Summary

In this section we have presented core requirements for the glasses system, these exist of four primary levels:

1. Physical
2. Cognitive
3. Interaction
4. Social

The four levels set out principles within the eGlasses project and are intended to shape the final design of the system. Their objective is to alert the designers/developers of the system to requirements which can apply across the project and not simply within individual use cases. This is the first iteration of such design principles and we expect them to evolve over time.

4 Modules and general requirements

All tasks specified in the work plan were divided into modules. Each module is understood as a thematically coherent unit of hardware or software. Most of the research activities in the project should be experimentally verified. Therefore, proposed methods should be implemented as hardware (H), software library (L) and/or as an application (A). Collections of subset of hardware and software libraries can be used to verify a proposed scientific hypothesis or can be used to create an application to demonstrate a developed method in the field of human-system interactions.

All modules will be developed based on the assumed general architecture of the eGlasses platform, presented in Fig. 1.

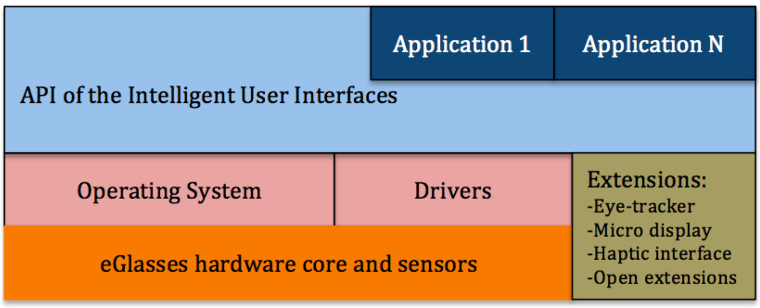

Fig. 1. The general architecture of the eGlasses platform

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4.1 Hardware

In this document only general requirements are presented. Detail requirements will be specified (as the extension of this document) together with the realization of particular work packages focused on hardware and methods. The additional report will be prepared for the state of the art and specification of hardware for the eGlasses platform.

The list of hardware modules is presented in the following set of tables.

	WP3.H1	Tasks	T3.1, T3.2	Responsible	Adam Bujnowski (GUT)
Name of the module				Microprocessor board for eGlasses core platform	
Functional requirements				Provides all operations on data	
Non-functional requirements				-High performance (2 or more cores, and graphical processor) -Low power consumption -Small size -Low heat emission -Optionally wireless communication modules -Interfaces: UART, I2C, SPI, USB, CSI/DSI, other	

	WP3.H2	Tasks	T3.3, T4.1	Responsible	Adam Bujnowski (GUT)
Name of the module				Eye-wear platform (motherboard)	
Functional requirements				Provides all operations on data	
Non-functional requirements				- Large field of view (camera) - Low (wearable) weight - Sockets for the exchangeable microprocessor board - Interface for exchangeable displays - Wireless communication modules - Front camera, - A microphone - A speaker - A set of sensors (temperature sensor, accelerometer, other) - Sockets and interfaces for extension modules	

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	(UART, I2C, SPI, USB, other)

	WP4.H3	Tasks	T4.1	Responsible	Jerzy Wtorek (GUT)
Name of the module				Eye-tracker hardware	
Functional requirements				Provides information about eye-movements Provides information about gaze direction Provides sequences of eye-images with at least 10fps	
Non-functional requirements				- Large field of view - Low weight - Eye-observation camera (NIR) - NIR/visible backlight	

	WP4.H4	Tasks	T3.3, T4.1	Responsible	Jacek Rumiński (GUT)
Name of the module				Displays hardware	
Functional requirements				Provides graphical information for a user Provides visualization of images captured by cameras Provides visualization of generated or rendered images	
Non-functional requirements				- Low weight - Different variants of the realization of modules: opaque, semi-transparent, beam projector - Low power consumption - Backlight control	

	WP4.H5	Tasks	T4.1	Responsible	Jerzy Wtorek (GUT)
Name of the module				Proximity radar hardware	
Functional requirements				Provides information about distance to an obstacle Provides feedback in the form of vibrations (a set of micro-vibrators or other haptic interface) Provides a connection to the display for visual feedback	
Non-functional requirements				- Low weight and small size - High sensitivity and selectivity - Low power consumption	

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4.2 Software libraries

Software library modules represent two groups of packages: low level and high level. Low-level software modules will be developed to support hardware modules (e.g. drivers) and to provide an interface for high-level modules. It is initially assumed, that the Linux kernel will be used as a base for operating systems. Two operating systems will be analyzed: Linux (e.g. Ubuntu) and Android. Essentially, Android runs on top of a standard Linux kernel. The Linux kernel in Android uses drivers that are loaded and maintained by the kernel. Low-level modules will be implemented in the kernel space and partially in the user space (Fig. 2) of the operating system.

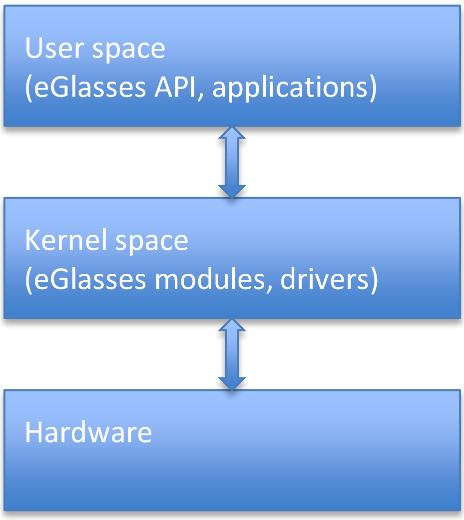

Fig. 2. General architecture of the Linux-based system

High-level software packages will be developed based on standard libraries including: Linux, Android API, and OpenCV API. The eGlasses API will provide interfaces and utility libraries for possible applications. It is initially assumed that the eGlasses API will be provided for both Linux OS (Linux and OpenCV APIs) and Android OS (Android and OpenCV APIs). The high level software modules will be provided based on standard algorithms already implemented in the existing APIs (Android API/SDK and OpenCV API) and as a result of research undertaken during the realization of eGlasses project.

In this document only general requirements are presented. Detailed requirements will be specified (as an extension to this document) together with realization of particular work packages focused on hardware and methods.

The list of software modules is presented in the following set of tables.

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	WP3.L5	Tasks	T3.4	Responsible	Adam Bujnowski (GUT)
Name of the module				Self diagnostics of the platform	
Functional requirements				Provides information about the state of the platform and hardware modules Provides functions to control hardware modules	
Non-functional requirements					

	WP4.L6	Tasks	T4.2	Responsible	Jerzy Wtorek (GUT)
Name of the module				Eye-tracker interactions	
Functional requirements				Provides information about the state of the eye-tracker Provides eye-observation video stream Provides video stream from front camera Provides functions to control the eye-tracker modules Provides functions to calibrate the eye-tracker Provides functions about the gaze direction Provides functions for gaze-based communication	
Non-functional requirements					

	WP4.L7	Tasks	T3.4, T4.2	Responsible	Jacek Rumiński (GUT)
Name of the module				Display rendering	
Functional requirements				Provides information about the type and the state of the display Provides function to send video stream to the display Provides functions to control the display module	
Non-functional requirements					

ID	WP4.L8	Tasks	T3.4, T4.2	Responsible	Jerzy Wtorek (GUT)
Name of the module				Proximity radar control	

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Functional requirements	Provides information about the type and the state of the proximity radar Provides functions to read information about distance to obstacles Provides functions to control micro-vibrators or other haptic interface
Non-functional requirements	

	WP4.L9	Tasks	T3.4, T4.2	Responsible	Adam Bujnowski (GUT)
Name of the module				Reading of sensor data	
Functional requirements				Provides information about the type and the state of sensors Provides prototypes of functions to be used in new extensions of the platform Provides functions to read sensor data Provides functions to control sensors	
Non-functional requirements					

	WP5.L10	Tasks	T5.2, T5.3	Responsible	Michael Haller (MIL)
Name of the module				Eyes-free interaction input modality	
Functional requirements				Recognize certain input metaphors (e.g., gestures) Report certain input metaphors (e.g., gestures)	
Non-functional requirements					

	WP6.L11	Tasks	T6.2	Responsible	Jacek Rumiński (GUT)
Name of the module				Face recognition and person identification	
Functional requirements				Provides functions for face detection within an image / a frame Provides functions for the identification of a person based on face features (and optionally on other, contextual information) Provides functions for the identification of a person based on artificial markers	
Non-functional					

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requirements	

	WP6.L12	Tasks	T6.3	Responsible	Jacek Rumiński (GUT)
Name of the module				Pulse and respiration rate recognition	
Functional requirements				Provides functions for a pulse measurement using a sequence of face images Provides functions for a respiration rate estimation using a sequence of face images	
Non-functional requirements					

	WP6.L13	Tasks	T6.4	Responsible	Adam Bujnowski (GUT)
Name of the module				Processing of voice commands	
Functional requirements				Provides functions for the recognition of simple voice commands	
Non-functional requirements				The module should use one of the existing speech recognition engines (CMU Sphinx, ISIP, Julius, Julian and HTK).	

	WP6.L14	Tasks	T6.4	Responsible	Benoit Martin (UL/LCOMS)
Name of the module				Database retrieval (CUDA)	
Functional requirements				Provides functions to control a database Provides functions to retrieve data about recognized person Provides functions to retrieve data about recognized object Provides functions to add data about recognized person Provides functions to add data about recognized object	
Non-functional requirements					

	WP7.L15	Tasks	T7.2	Responsible	Benoit Martin (UL/LCOMS)
Name of the module				Object detection and identification	
Functional requirements				Provides functions to detect objects based on graphical features Provides functions to detect objects based on artificial markers	

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	Provides functions to distinguish objects with similar features (e.g. using contextual information, topology of sensor networks and time differences, etc.).
Non-functional requirements	

	WP7.L16	Tasks	T7.5	Responsible	Benoit Martin (UL/LCOMS)
Name of the module				Navigation at home	
Functional requirements				Provides functions for the localization of objects at home Provides functions to guide a person to the given location	
Non-functional requirements					

	WP7.L17	Tasks	T7.2	Responsible	Martin Biallas (iHomeLab)
Name of the module				Control of recognized objects	
Functional requirements				Provides functions for the communication with sensor nodes and controllable objects Provides functions for the exchange of information and code related to the control of recognized objects	
Non-functional requirements					

	WP7.L18	Tasks	T7.3	Responsible	Jacek Ruminski (GUT)
Name of the module				Color identification	
Functional requirements				Provides functions for the color recognition Provides functions for the color identification and presentation of the color label (e.g. name) Provides functions for color modifications within an image (e.g. simulation of colors for dichromats)	
Non-functional requirements					

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4.3 Summary

Based on this general specification the detail specifications will be prepared for particular modules. Some modules can be changed, added, deleted, etc., according to the nature of hardware and software engineering and according to the progress in research studies in the filed human-computer interactions.

Finally, a set of demonstration applications will be developed based on the designed and implemented hardware modules and software library modules. The specification of requirements for those demonstration applications will be defined in the second half of the project realization period.

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