

Managing Affective-learning THrough Intelligent atoms and Smart Interactions

Pending of approval from the European Commission

D1.7 Affect Recognition Software

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Abstract:	This document presents detailed and step-by-step instruction set on how to use the MaTHiSiS Affect Recognition Tool (desktop and mobile versions). It includes a high-level description of the tools, information about licensing and ownership, their intended use, as well as technical guidelines on the installation and configuration of the application. The document also covers some basic functionalities in order to provide some insight on the applications' internal behaviour.
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List of Acronyms

Abbreviation / acronym	Description
AIR lib	Affect and Intent Recognition library
API	Application Programming Interface
AR-d	Affect Recognition tool – desktop
AR-m	Affect Recognition tool – mobile
CLS	Cloud-based Learner’s Space
DAT	Data Acquisition Tool
I/O	Input / Output
ITC	Industrial Training Case
LES	Learning Experience Supervisor
LM	Learning Material
MF	MaTHiSiS Front-end
PA	Platform Agents
PC	Platform Configuration
SC	Sensorial Component
UI	User Interface
UM-T	Users Management Tool
URM	User and Role Manager

Table 1: Definitions, Acronyms and Abbreviations

Project Description

The MaTHiSiS learning vision is to provide a novel advanced digital ecosystem for vocational training, and special needs and mainstream education for individuals with an intellectual disability (ID), autism and neuro-typical learners in school-based and adult education learning contexts. This ecosystem consists of an integrated platform, along with a set of re-usable learning components with capabilities for: i) adaptive learning, ii) automatic feedback, iii) automatic assessment of learners' progress and behavioural state, iv) affective learning, and v) game-based learning.

In addition to a learning ecosystem capable of responding to a learner's affective state, the MaTHiSiS project will introduce a novel approach to structuring the learning goals for each learner. Learning graphs act as a novel educational structural tool. The building materials of these graphs are drawn from a set of Smart Learning Atoms (SLAs) and a set of specific learning goals, which will constitute the vertices of these graphs, while relations between SLAs and learning goals constitute the edges of the graphs. SLAs are atomic and complete pieces of knowledge, which can be learned and assessed in a single, short-term iteration, targeting certain problems. More than one SLA, working together on the same graph, will enable individuals to reach their learning and training goals. Learning goals and SLAs will be scoped in collaboration with learners themselves, teachers and trainers in formal and non-formal education contexts (general education, vocational training, lifelong training and specific skills learning).

MaTHiSiS is a 39-month long project (originally 36-month long, extended after contract amendment), co-funded by the European Commission Horizon 2020 Programme (H2020-ICT-2015), under Grant Agreement No. 687772.

Executive Summary

This document reports on the progress and final solution of the **Affect Recognition Tool - desktop (AR-d)** for Windows devices and the **Affect Recognition Tool - mobile (AR-m)** for Android devices, developed as part of the MaTHiSiS project. It also demonstrates the in situ use of the application.

The document provides a detailed description of the application as well as a detailed guideline from the point of installation up to a full configuration of both the AR-d and the AR-m. The main component encompassed in both AR-d and AR-m are the functionalities of MaTHiSiS' Sensorial Component (SC). The SC functions as reported in MaTHiSiS deliverables D4.1 [1] and D4.2 [2] (*MaTHiSiS sensorial component*) and incorporates all of its original features and functionalities.

This document also offers a thorough explanation of the user interface, uniquely offered in both AR-d and AR-m, that enables the user to utilize and monitor a) each different affect recognition modality of the desktop SC, out of the four camera/microphone-based functionalities supported on the desktop by the SC (namely facial expression analysis, gaze estimation, skeleton motion analysis, audio-based analysis) and b) the inertial sensors-based affect recognition modality of the mobile SC. This UI is also in charge of a live presentation of the user affect states for each of the supported individual modality. For the case of AR-d, the UI also presents the fused affect, for the combination of individual desktop modalities that the user has selected to utilize and monitor.

While the application follows initial technical and user requirements, it is capable of functioning on the background of any application. By keeping all external communications to a minimum, it is independent of the MaTHiSiS platform, while taking advantage of the MaTHiSiS algorithms to calculate and exhibit the users' affect states.

1. Introduction and preliminaries

1.1 Document purpose and context

The purpose of this document is to provide the users of the MaTHiSiS **Affect Recognition tool desktop** (abbreviated in this document as **AR-d**) and **Affect Recognition tool mobile** (abbreviated as **AR-m**) tools with an overview of the tools, as well as with easy-to-follow instructions, in order to install, configure and use the application. It is divided into two major sections, one for each tool (AR-d and AR-m respectively), each starting with information about their intended use and licensing/ownership details, moving then on to present the installation process with details that guide the user throughout the whole process step-by-step. An explanation of the applications User Interface (UI) follows. The document describes the functionalities of the UI buttons, as well as the flow of the user interactions, in order to use the application properly. Concluding each section, the applications dependencies and any additional programs or required files are reported. Finally, the APIs used in the application are briefly presented.

1.2 Intended use of the Affect Recognition software

The AR-d and AR-m use data retrieved from common sensors like web cameras and gyroscopes. This data is processed on-the-fly by the MaTHiSiS deep learning-based affect recognition algorithms to ultimately identify the affect state of the user while they are performing tasks on a desktop computer or interacting with a NAO robot (AR-d) or using their mobile device (AR-m). Those affect states are then presented with numerical values in respective diagrams on the AR-d and AR-m UIs.

The main goal of the AR-d and AR-m is to assist teachers/parents/caregivers/independent learners in monitoring the students affect states, while they are engaged in other exercises or activities. This way, teachers/parents/caregivers may be more efficiently equipped to guide the students in learning through more engaging activities/educational material, tailored to the student's individual needs and learning styles, and as a result, enhance the quality of the learning process in general. On the other hand, individual learners may more efficiently assess and adjust their learning progress and potentially re-evaluate and better prioritise their learning objectives.

The unobtrusive, real-time affect recognition and visualisation process make the AR-d and AR-m tools versatile and suitable to many applications, beyond the field of education. The AR-d and AR-m applications can be employed on various other fields as well e.g. in the workplace, where an employer wants to motivate his employees and decides to adjust their corresponding activities based on their emotional states, or on the field of psychology, where it could lead to a better understanding and monitoring of a patient's mood and disposition towards undertaken activities.

Although the AR-d and AR-m do not store any personal data captured by sensors (e.g. images, video), their usage involves handling sensitive data, i.e. the recognised affect state. As a result, care should be taken during its distribution and its usage should be allowed only with user/caretaker/parental consent.

1.3 Dependencies and preconditions

This subsection will detail all dependencies and preconditions that govern the usage of the AR-d and AR-m.

1.3.1 Dependencies of the AR-d

The AR-d has the following dependencies:

- Microsoft Windows 8.1 or newer
- KinectSDK-v2.0_1409 (provided with the installer)
- Visual C++ Build Tools 2015 (provided with the installer)

1.3.2 Dependencies of the AR-m

The application requires a mobile device with Android version 5 or higher.

1.3.3 Preconditions of the AR-d and AR-m

Both the desktop and mobile versions of the Affect Recognition software needs to communicate with the MaTHiSiS Open APIs/cloud services (CLS). Therefore, the network of the workstation that runs the AR-d or of the mobile device that runs the AR-m must provide access to **ports 80,443 and 7000** - and if needed, to also manually allow access to the root URL of the CLS installation¹ and the central CLS websocket server:

1. https://<root_CLS_URL>/, e.g. <https://prod.mathisis-project.eu/>
2. **wss://<root_CLS_URL>:7000**, e.g. **wss://prod.mathisis-project.eu:7000** - please note that this in **NOT** http.

Firewall restrictions to the web and the aforementioned locations must be disabled.

For institutions and corporations that **have very strict firewall restrictions**:

- Some ports have to be manually allowed from the system administrator of the venue.
- The main port (7000) is where the Affect Recognition software communicate with the cloud. This port needs to be open, otherwise the platform won't communicate with the devices at all.

In case you notice that one or both of the tools are not connecting to the network in a particular institution/workplace, which may have network and firewall restrictions, please contact the local network administrator and ask them to allow connection to the ports mentioned above.

1.4 Document structure

The rest of this document is structured as follows:

- **Section 2:** Affect recognition tool - desktop (AR-d)
 - **Chapter 2.1:** Overview of the MaTHiSiS Affect Recognition desktop Tool (including licensing information)
 - **Chapter 2.2:** Installation of the MaTHiSiS Affect Recognition desktop Tool
 - **Chapter 2.3:** Configuration of the MaTHiSiS Affect Recognition desktop Tool
- **Section 3:** Affect recognition tool - mobile (AR-m)
 - **Chapter 3.1:** Overview of the MaTHiSiS Affect Recognition mobile Tool (including licensing information)
 - **Chapter 3.2:** Installation of the MaTHiSiS Affect Recognition mobile Tool
 - **Chapter 3.3:** Configuration of the MaTHiSiS Affect Recognition mobile Tool
 - **Chapter 3.4:** Architecture of the MaTHiSiS Affect Recognition mobile Tool
- **Section 4:** Conclusion

¹ If using an online installation of the CLS provided by the MaTHiSiS project, please advise get in touch with MaTHiSiS platform support at <http://mathisis-project.eu/en/content/mathisis-platform>. In the case where a local installation of the MaTHiSiS platform is used, the URL must reflect the local server's configuration.

2. Affect recognition tool - desktop (AR-d)

2.1 Overview

The AR-d is a tool that is able to recognise and display the affect state of a user performing tasks on a desktop computer or interacting with a NAO robot. In the current implementation, the use of the tool is restricted to Windows desktop PCs or laptops, version 8.1 or higher.

The user's affect state is identified based on data retrieved by common sensors like web cameras. The AR-d tool, as the name states, can be used separately from MaTHiSiS' modules² in any possible scenario that would require monitoring and recognising the user's affect. It includes all of the necessary features of the MaTHiSiS platform, in order to be able to operate in the background of each desktop application and while interacting with a NAO robot.

Specifically, the AR-d employs all of the MaTHiSiS supported sensors (web camera, NAO robot, Kinect) and their corresponding modalities:

- Face : Affect states based on facial expressions
- Gaze : Affect states based on human eye-gaze
- Skeleton : Affect states based on human skeleton movement, as captured from Kinect devices
- Sound: Audio-based affect states (only Kinect-retrieved audio can be used in the current implementation)

With sensorial data from those modalities, in conjunction with the MaTHiSiS affect recognition algorithms, the AR-d extracts affect states. Those affect states are then schematically visualised on the tool's UI.

2.1.1 Licensing and ownership

The AR-d is available for use under the ISC License (ISC)³, with the Centre for Research and Technology Hellas (CERTH)⁴ as copyright holders and main creators. Co-creators of the tool is the National Centre of Scientific Research "Demokritos" (NSCR)⁵.

2.2 Installation of the MaTHiSiS Affect Recognition desktop (AR-d) tool

The following subsection will guide the reader of this document towards the installation and setup of the AR-d tool, which can be downloaded from the MaTHiSiS website: <http://mathisis-project.eu/en/content/affect-recognition-software>

² I.e. it doesn't need to be used in a MaTHiSiS-powered learning session or scenario, or use any of the modules of the full MaTHiSiS workflow that aren't purely dedicated to fuse affect states from different modalities, which are recognised locally on the user's device based on used sensors

³ <https://www.isc.org/downloads/software-support-policy/isc-license/>

⁴ <https://www.certh.gr/>

⁵ <http://www.demokritos.gr/?lang=en>

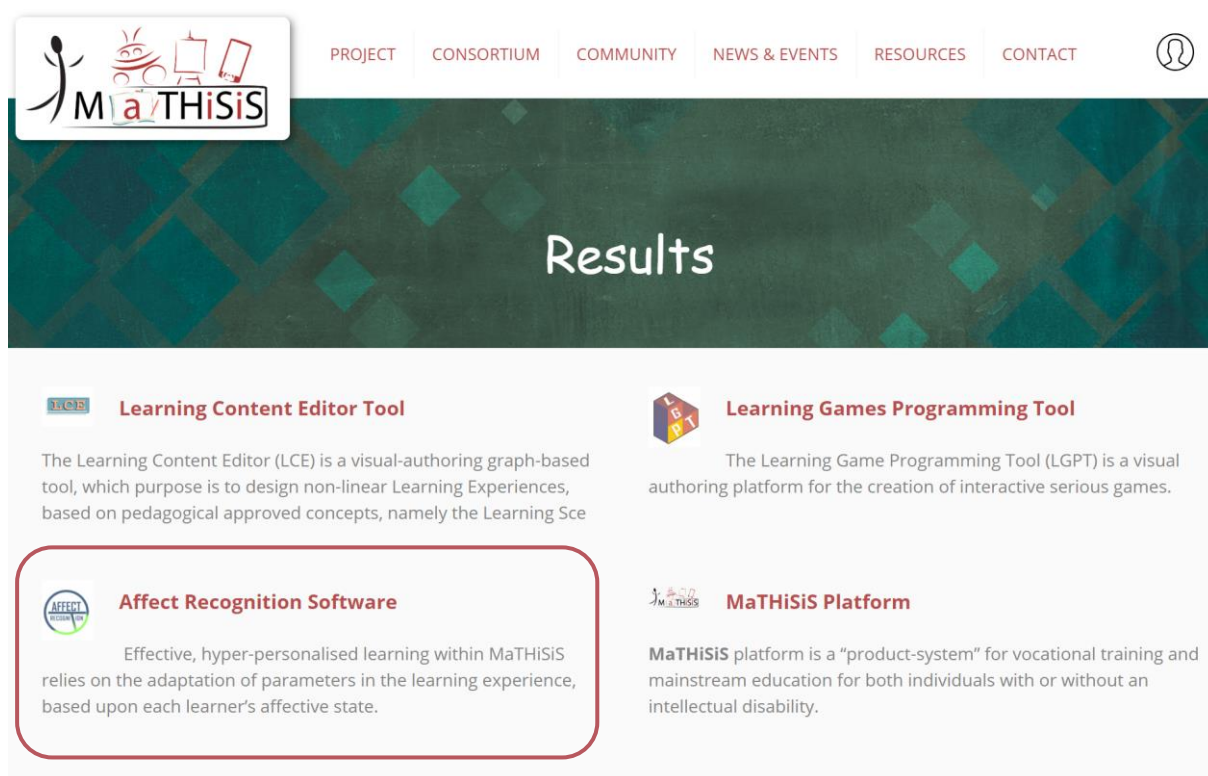


Figure 1 MaTHiSiS Results downloads section

By following the tab of **Affect Recognition Software** user will be able to download packages of desktop and mobile versions of the tool. The desktop version pertains to the files "AR-d Instructions.txt" and "MaTHiSiS_Affect_Recognition_Toolx.x.x.x.exe" (x.x.x.x = version, current is 1.0.0.0).

After downloading the files, proceed with the following steps:

- Double click on the **MaTHiSiS_Affect_Recognition_Toolx.x.x.x.exe** installer and follow the wizard to install the software.
- The "**AR-d Instruction.txt**" extracted during installation and placed on the root folder where the tool was installed.
- Follow the installation wizard. Select installation folder name and location (default is "C:\MaTHiSiS_Affect_Recognition_Tool"):

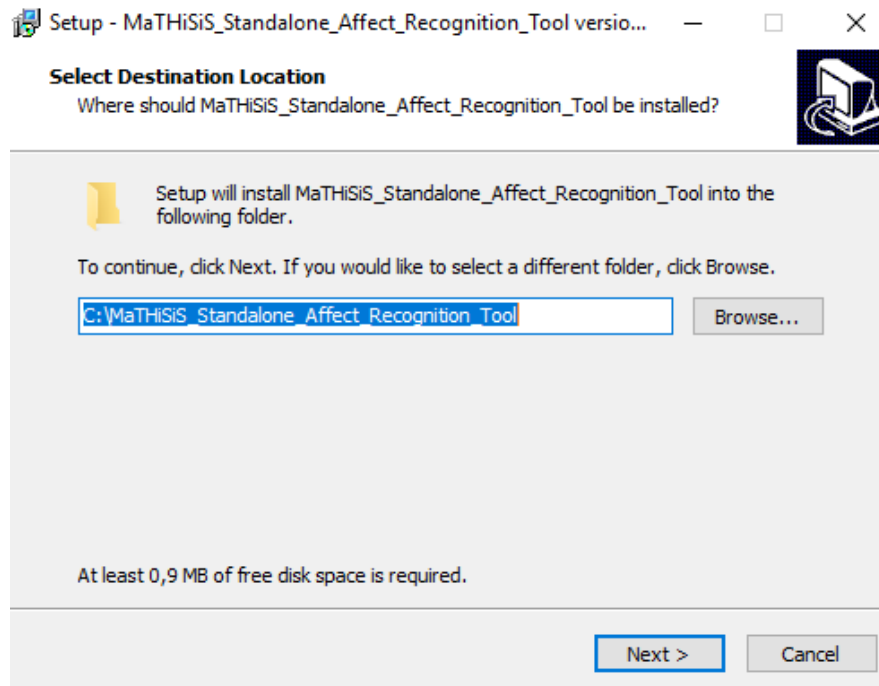


Figure 2: Installation of the AR-d tool (1)

- Choose “Full Installation” and select the “MaTHiSiS Affect Recognition Tool” component:

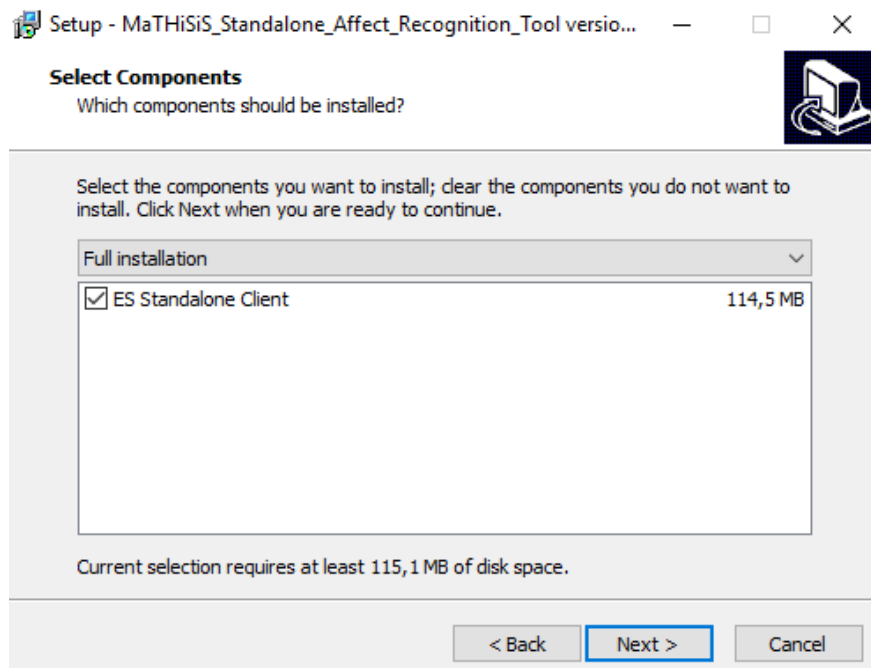


Figure 3: Installation of the AR-d tool (2)

- Select start menu folder name of the installation:

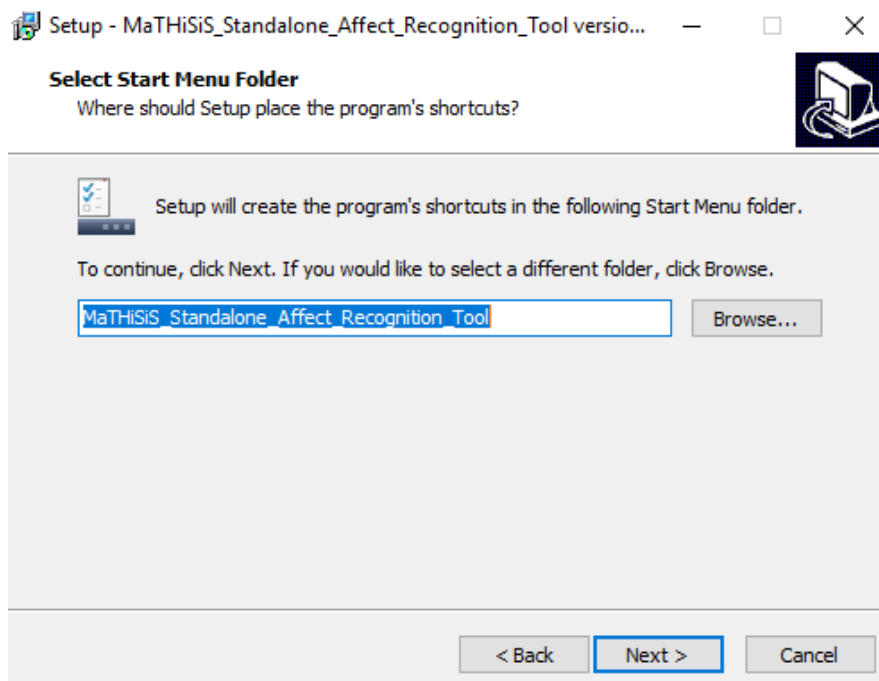


Figure 4: Installation of the AR-d tool (3)

- Choose whether a desktop icon will be created for the application:

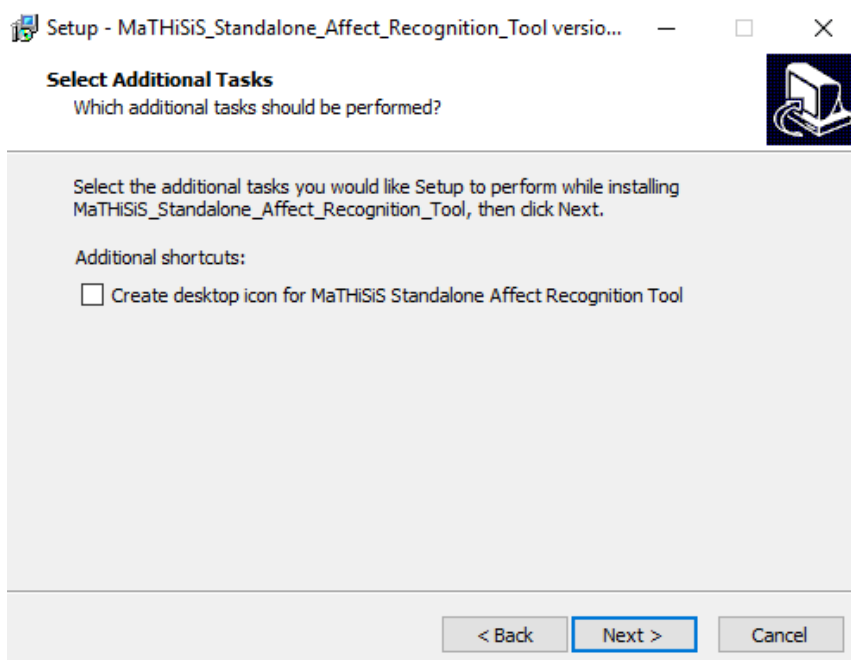


Figure 5: Installation of the AR-d tool (4)

- The final step displays an overview of the installation details:

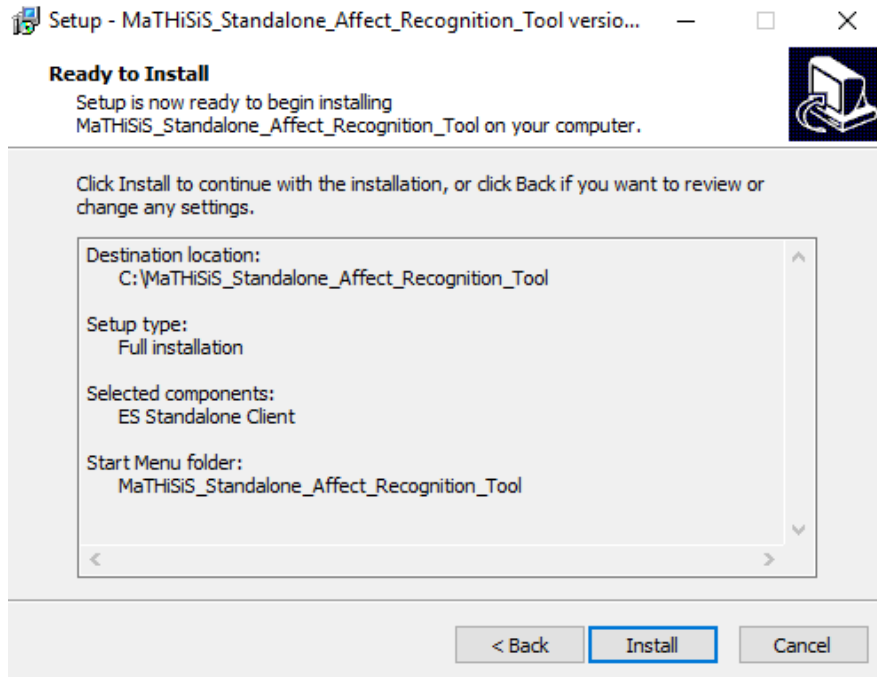


Figure 6: Installation of the AR-d tool (5)

- On pressing the "Install" button, the installer downloads extra packages needed for the installation of the Sensorial Component from the MaTHiSiS platform. If for some reason the connection fails during the download process, either cancel and restart, or wait for the connection issue to be resolved and continue.

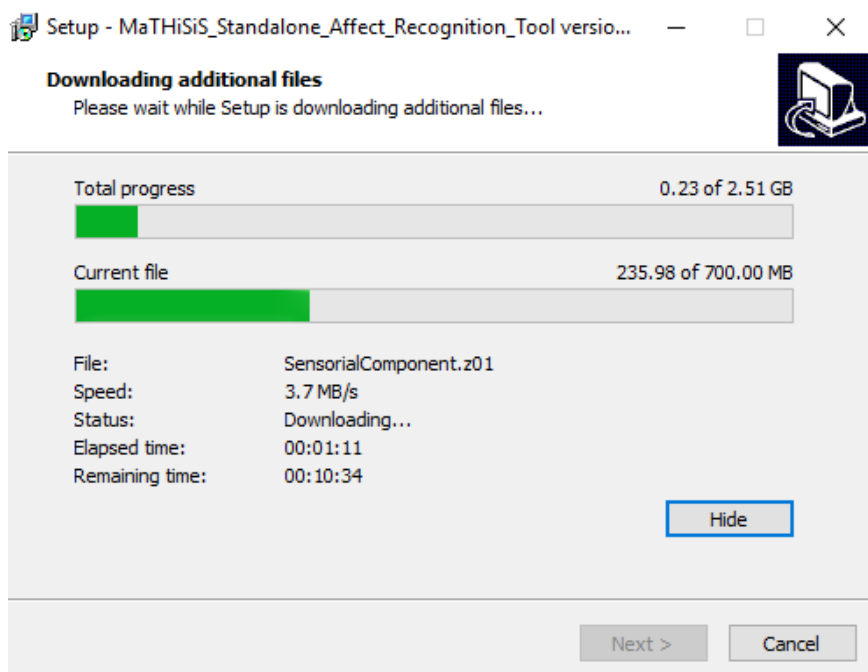


Figure 7: Installation of the AR-d tool (6)

- The installation process concludes with extracting the downloaded Sensorial Component parts into the installation folder. Please wait for the dialog box to shut itself down after completing all extraction and installation tasks.

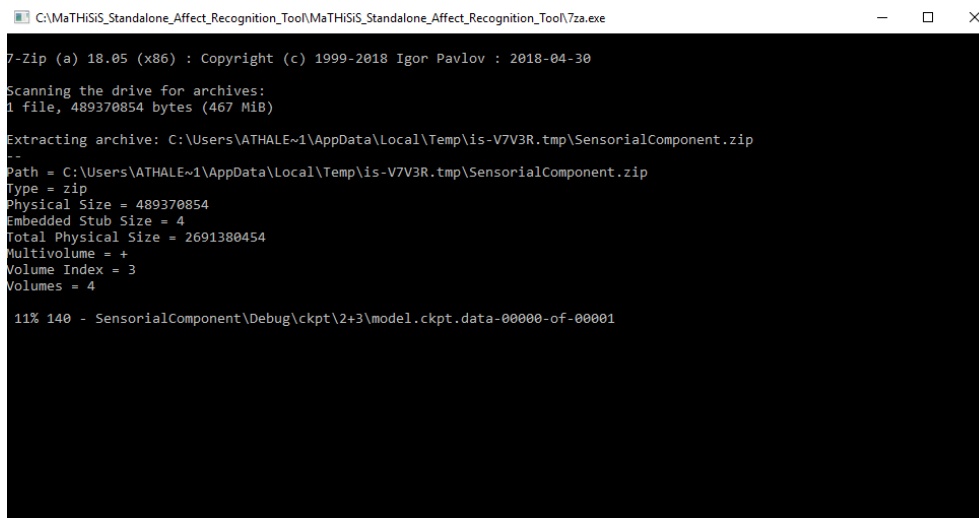


Figure 8: Installation of the AR-d tool (7)

- After the extraction is complete, choose to install **KinectSDK** and **Visual C++ build** tools *ONLY* if not previously installed in the current PC/laptop. This is free-to-use Microsoft software, essential for the full use of all affect recognition component. If you have this software already installed on the machine, please finish with installation wizard without selecting to download this software:

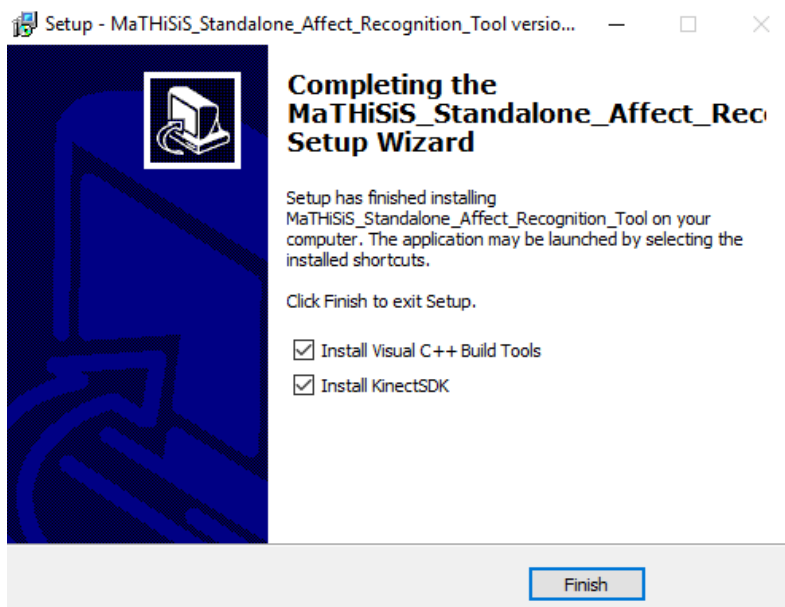


Figure 9: Installation of the AR-d tool (8)

The application will be installed on drive C: under the **MaTHiSiS Affect Recognition Tool** folder (by default, if no other option is elected during installation).

In case the application needs to be uninstalled, please go to **C:/ MaTHiSiS Affect Recognition Tool/uninstall** or to <installation folder>/uninstall.exe in case of a non-default installation folder.

2.3 Configuration of the MaTHiSiS Affect Recognition desktop tool

In order to run the application, double click on the **MaTHiSiS_Affect_Recognition_Tool.exe** from the folder **C:/ MaTHiSiS Affect Recognition Tool/** or from the desktop shortcut created during installation (if opted).

If this is the first time the application is used, a pop-up appears requesting for the Server address. By default ('Cancel' option) the AR-d tool uses the default MaTHiSiS server. If a new server is entered, another pop-up appears, requesting for the servers Port number, as displayed in the following pictures. Care should be taken while entering the servers name. The name should start without any prefix e.g. `https://`, or `wss://`. (example : `prod.mathisis-project.eu`)

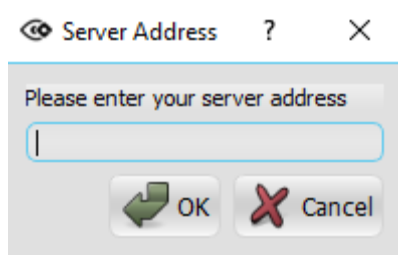


Figure 10: Server Selection

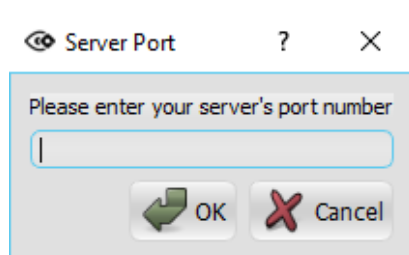


Figure 11: Port Selection

The main user interface is displayed. The language used in the application can be modified by pressing the "Set Language" button, selecting from available languages (English, French, Italian, Spanish, Greek). You will need to restart the application for language modification to take effect.

Upon launching the application, the Sensorial Component will run as a background application and the Affect Recognition tool will start searching for available connected sensors (web camera, kinect, NAO robot). For the cameras, the application will scan the system hardware connected. For NAO robots, the application will scan the entire network that the current PC is connected to. Once the available sensors are retrieved, their respective buttons, as well as the "Start" button, are enabled on the user interface.

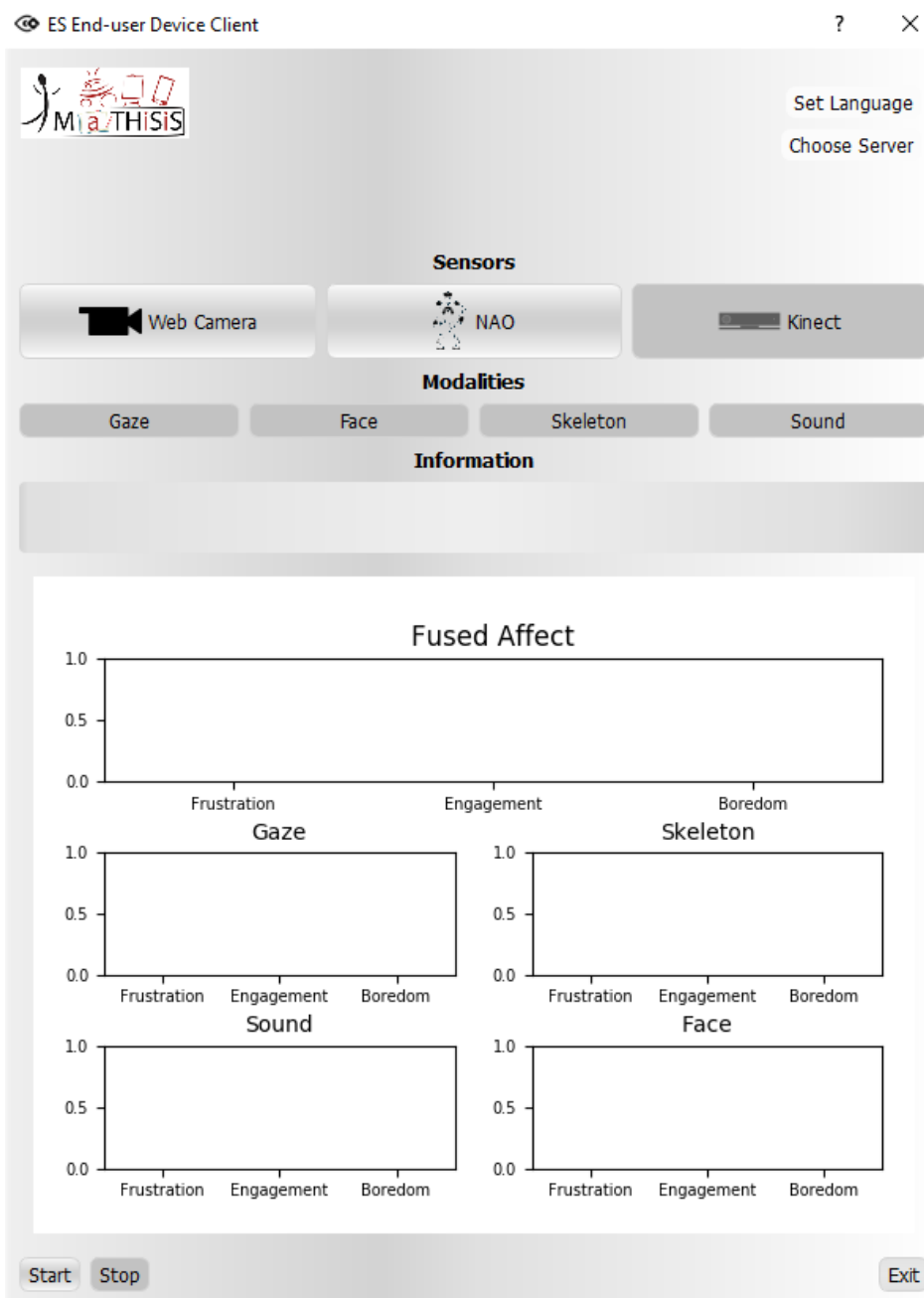


Figure 12: AR-d tool user interface – initialization

Figure 13 exemplifies a case where only a Web Camera is connected to the workstation and no NAO robot is available on the network. By selecting the desired sensor, the available affect recognition modalities that can be supported by that sensor are enabled (Figure 14).

For the time being, through the use of a Web camera or a NAO robot, only facial expression analysis and gaze estimation can be utilized for affect recognition, while with the use of a Kinect v2 stereoscopic camera, all four modalities (facial expression analysis, gaze estimation, skeleton motion analysis, audio-based affect recognition) can be utilized.

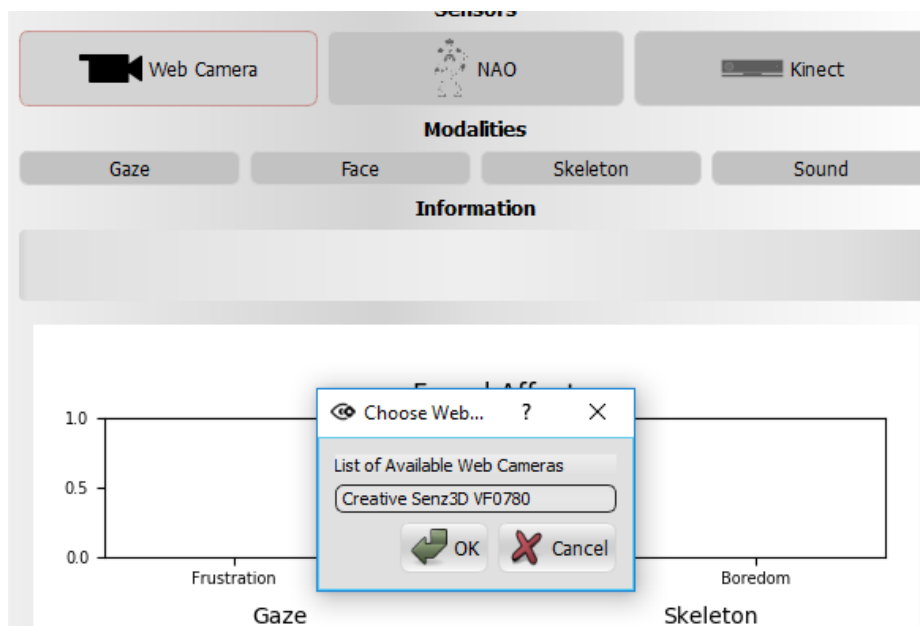


Figure 13: Choosing desired webcam from available webcam devices.

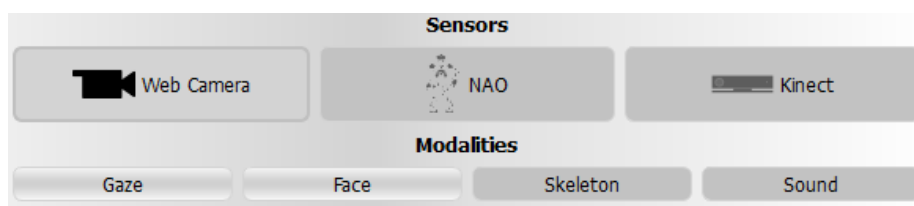


Figure 14: Available modalities for chosen sensor.

After pressing “Start” (Figure 12), every approximately 20 seconds, the Affect Recognition tool gathers all sensorial information and displays the affect state of the user for each of the enabled modalities, as well as for the combination thereof as a single overall (fused) affect state.

Those states are presented in the five figures on the user’s interface. The four bottom figures correspond to the four individual sensorial modalities that can be used (skeleton, face, gaze, sound). The figure on top represents the fused affect states, as calculated from the MaTHiSiS online platform.

All of the previously calculated affect states received by the application are stored in a .csv file (affect_states.csv) inside the source folder of the application. This log includes the entire history of recognised affect states since the application’s installation, marked by time. The .csv file can be used to plot the entire affect recognition history for the current workstation.

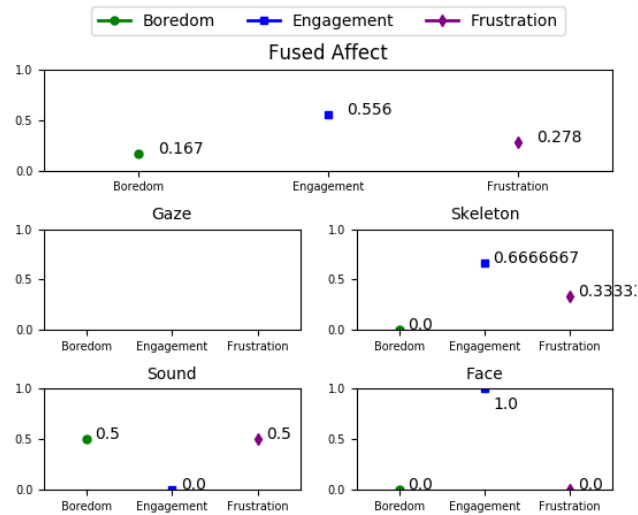


Figure 15: Affect state recognition visualization. Fused affect is displayed on the top, while four individual charts display the affect recognised by each individual chosen modality (here, skeleton motion analysis, gaze estimation and audio-based analysis are selected).

By pressing the “Stop” button, the affect recognition session ends and the final results are displayed on the visualisation panel (Figure 15). The application stands by, waiting for a new session to start, or for the user to terminate the application through the “Exit” button.

3. Affect recognition tool - mobile (AR-m)

3.1 Overview

The AR-m recognises and displays the affect state of a user performing tasks on mobile devices (smartphone or tablet). In the current implementation, the use of the tool is restricted to Android mobile devices, version 5 or higher.

The user's affect state is identified based on data retrieved by standard mobile inertial sensors (i.e. gyroscope, touch panel, accelerometer). The AR-m tool, can be used separately from MaTHiSiS' modules⁶ in any possible scenario that would require monitoring and recognising the user's affect through mobile devices. It includes all of the necessary features of the MaTHiSiS platform, in order to be able to operate as an independent mobile application, recognise the affective state of a mobile device's user through the MaTHiSiS inertial sensor-based affect recognition algorithm, and then visualise this affect state on the tool's UI, through suitable labels.

3.1.1 Licensing and ownership

The AR-m is available for use under the LGPLv3 license⁷, with OTE Academy (OTEA)⁸ and the University of Maastricht (UM)⁹ as copyright holders and co-creators.

3.2 Installation of the MaTHiSiS Affect Recognition mobile (AR-m) Tool

The following subsection will guide the reader of this document towards the installation and setup of the AR-m tool, which can be downloaded from the MaTHiSiS website following the link <http://mathisis-project.eu/en/content/affect-recognition-software> under "Mobile".

Following the link, the user will be able to install the application following the steps:

- Copy the **MaTHiSiS_Affect_Recognition_Toolx.x.x.apk** file into a mobile device with Android (Android version 5 or higher)
- Open (by tapping on it) the **MaTHiSiS_Affect_Recognition_Toolx.x.x.apk**
- Follow the default Android installation wizard.

3.3 Configuration of the MaTHiSiS Affect Recognition mobile Tool

In order to run the application, tap on the **MaTHiSiS ART**¹⁰ icon that you can find in the mobile device menu.

⁶ I.e. it doesn't need to be used in a MaTHiSiS-powered learning session or scenario, or use any of the modules of the full MaTHiSiS workflow that aren't purely dedicated to recognise inertial sensor-based affect states, based on anonymised sensorial information retrieved from the mobile device's sensors, transmitted only once and never stored on the cloud

⁷ <https://opensource.org/licenses/lgpl-3.0.html>

⁸ <https://oteacademy.gr/el/>

⁹ <https://www.maastrichtuniversity.nl/>

¹⁰ While AR-m is the acronym used to distinguish the mobile from the desktop version of the Affect Recognition Tool, this distinction is not necessary on-device, therefore the name of the mobile app is maintained in a generic form, i.e. ART (standing for Affect Recognition Tool).

The main user interface is displayed. Upon launching the application, the Sensorial Component will run as a background application and the AR-m will start gathering sensorial data for available sensors (gyroscope, accelerometer, touch screen).

After pressing “Start”, every approximately 20 seconds, the AR-m gathers all sensorial information and displays the affective state of the user.

All of the previously calculated affect states received by the application are stored in a local (SQLite) database on the mobile device and all data is deleted when the application closes.

By pressing the “Stop” button, the affect recognition session ends and the final results are displayed on the screen, as seen in Figure 16. The application stands by, waiting for a new session to Start, or for the user to terminate the application through the “Exit” button.



Figure 16: The UI visualisation of the user's affect state on AR-m

3.4 Architecture of the MaTHiSiS Affect Recognition mobile Tool

The mobile application consists of two main services. The first service is the Sensorial Component (mobile aspect – i.e. the component which is responsible for the mobile sensorial data gathering) while the second is the Manager Component which is responsible to handle the communication with the Cloud-residing (CLS) Open APIs and the User Interface.

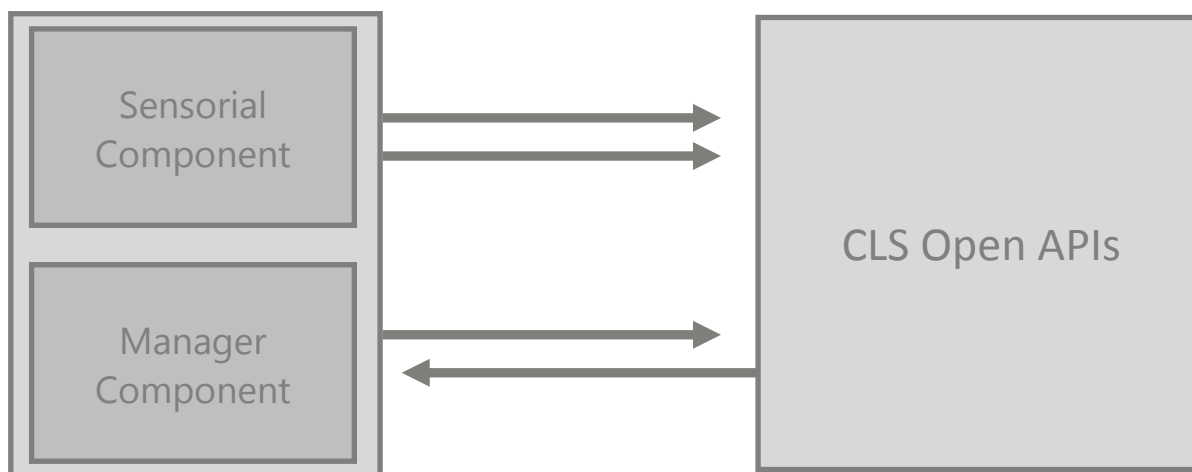


Figure 17 AR-m Tool architecture

The Manager Component communicates with the cloud through REST API Calls. The first endpoint is used for the sensorial data exchange. The endpoint is:

`http://<root_CLS_URL>/airlib/api/mobileStandaloneSensors/{device_id}`

The cloud service is intended to serve as endpoint for the sensorial information from mobile devices. Once this information is received, it performs the calculation of the affective state based on these data and saves the data in a dedicated collection. As input, it requires a json object of the following format:

```

{
  "device_id": the unique device identifier,
  "features": [],
  "Timestamp": "ISODate"
}
  
```

In the features position, the data from the Sensorial Component is communicated.

Furthermore, the Manager Component uses a second endpoint which is called to retrieve the calculated affect state for the specific device that user uses. The endpoint is

`http://<root_CLS_URL>/airlib/api/mobileStandaloneAffect/{device_id}`.

The cloud service is defined as the endpoint used to retrieve the affective state calculated based on the sensorial information from mobile devices and the structure of the payload that returns is:

```
{  
  "affective_state":"string (valid values: Boredom, Frustration and Engagement)",  
  "max_index":"integer",  
  "Max_scored":"integer",  
  "normalized_score":"[float, float, float] (probabilities for Boredom, Frustrati  
on and Engagement respectively)"  
}
```


4. Conclusion

This document provided on overview and technical documentation of the Affect Recognition software commercial package (desktop and mobile versions), one of the 4+1 commercial packages produced and delivered as outcomes of the MaTHiSiS project.

Through the main MaTHiSiS project website, this software is ready to be distributed and commercially exploited by third-party stakeholders of the educational domain and beyond.

The main goal of the document is to motivate and guide interested stakeholders to download, install and run the application for their own purposes.

5. References

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