

Summary of the context and overall objectives of the project (For the final period, include the conclusions of the action)

3D Tune-In (3DTI) is an EU-funded project coordinated by the Dyson School of Design Engineering at Imperial College London (2015-2018), which brings together the relevant stakeholders from the videogame industry, academic institutions, a large hearing aid manufacturer, and hearing communities, to produce digital games in the field of hearing aid technologies and hearing loss.

Using a participatory-design process involving relevant stakeholders (human factors experts, technology developers, hearing communities, end-users) the 3DTI project aims to:

- Enable end users to explore, review and customize hearing aid devices for different usage scenarios
- Enable individuals with no hearing impairment to understand how hearing loss can compromise everyday activities, and how a hearing aid can improve this situation
- Enable gaming SMEs to explore new non-leisure applications in the area of hearing loss and hearing aid technology with support from the scientific community
- Enable hearing aid providers to evaluate and demonstrate the various functionalities of their products to improve their services and increase sales

During the course of the project, several libraries and applications have been developed, including the 3DTI Toolkit (a standard C++ library for audio spatialization and simulation of hearing loss and hearing aids) and Applications (five applications, each of which aim to improve the lives of those affected by hearing loss). All the developed components have been created employing a participatory design approach, a series of AGILE development/evaluation loops, and a final summative evaluation.

The dissemination of the project has been particularly successful, including scientific and industry dissemination activities, journals and magazines publications, and attendance to several national and international conference venues. Also the exploitation has been particularly successful; the Toolkit has been released open-source, and has already shown a good success in terms of developers and researchers using it in their projects/studies. Each Application's exploitation plan has been carefully planned, and is currently undergoing; an example is <http://www.hearingamestudio.com/>, a joint effort of the 3DTI Italian partners for the exploitation of their Applications.

All project outputs, material and deliverables can be found on the project website:

- 3DTI Toolkit – <http://3d-tune-in.eu/toolkit-developers>
- 3DTI Applications - <http://3d-tune-in.eu/applications>
- Project public deliverables - <http://3d-tune-in.eu/Deliverables>
- Scientific publications - <http://3d-tune-in.eu/papers-publications>

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far (For the final period please include an overview of the results and their exploitation and dissemination)

During the course of the project we have developed the 3DTI Toolkit, a library which provides 3D audio simulations (both for loudspeakers and headphones) with a high level of realism and immersiveness, while allowing for the simulation of hearing aid devices and of different typologies of hearing loss. An easy-to-use test-app interface allows the Toolkit to be used by hearing aid users, audiologist and any other interested party without needing to go through complex code and settings. Using the Toolkit, it is possible to simulate complex listening environments (e.g. a train station or a noisy restaurant), and demonstrate how much a hearing aid could improve the situation without having to fully fit a real device, but just using our virtual one. Or again, users can simulate their specific hearing loss, and demonstrate to their family members how complicated it is to understand speech when other noises are present, as it happens for example at the dinner table. The Toolkit test-app can be downloaded and used for free directly from the project website (<http://3d-tune-in.eu/toolkit-developers>), while the open-source code can be accessed from our GitHub account (<https://github.com/3DTune-In/>).

In addition to the Toolkit, 3DTI has produced 5 different applications aimed at different groups of the hearing impaired and non-hearing impaired communities (<http://3d-tune-in.eu/applications>):

- Musiclarity. A web-based app which supports hearing impaired individuals and hearing aid users in listening music
- Dartanan. A mobile app for children, in order to help them learn about the functionalities of their hearing aid while playing a fun and engaging game.
- Play&Tune. A mobile app specifically designed for adult hearing aid users, which guides them through the different functionalities of the hearing aid using a simple and engaging interface.
- AudGamPRO. A loudspeaker-based desktop application for replicating the acoustic conditions of real-life scenarios (e.g. restaurant, street, etc.), in order to allow audiologists to verify if and how hearing aids have been fitted properly.
- Darius' Adventure. A mobile app for children without hearing problems, which aims to educate them about living with a hearing impairment, simulating the presence of hearing loss and engaging the child to try different hearing aids and communication strategies in order to improve their hearing.

All the developed components have been created employing a participatory design approach, a series of AGILE development/evaluation loops, and a final summative evaluation, which involved 319 participants in an online and/or paper-based survey after using one to five apps. Ultimately, all applications met their original goals, and have been released according to the project's exploitation plans.

Furthermore, all project outcomes have been communicated and disseminated according to the original plan, developed in the first months of the project and regularly updated.

Progress beyond the state of the art, expected results until the end of the project and potential impacts (including the socio-economic impact and the wider societal implications of the project so far)

The progress beyond the state of the art achieved during the 3DTI project can be summarised in the following points:

- **3DTI Toolkit.** The Toolkit includes several innovative functionalities, all integrated in a single open-source library, available also as an executable application (for MacOS, Windows and Linux), and as a wrapper for Unity and Javascript. This research represents a contribution to the state of the art in acoustics and signal processing research, and is currently being published.
- **HRTF studies.** A series of studies on Head Related Transfer Functions (HRTFs) selection, adaptation and individualisation has been carried out during the project. This research represents a contribution to the state of the art in acoustics and psychoacoustics research, and is currently being published.
- **3DTI Applications evaluation.** All the developed Applications have been created employing a participatory design approach, a series of AGILE development/evaluation loops, and a final summative evaluation, which involved 319 participants in an online and/or paper-based survey after using one to five apps. Data from these evaluations represents a contribution to the state of the art in human factors research and serious games, and is currently being published.

In terms of societal engagement, in addition to the participatory design and evaluation stages, which resulted in the involvement of more than 500 individuals (hearing aid users, hearing impaired individuals, audiologists, developers, and general public), the project reaches several communities through participation to conferences, workshops, showcases and seminars. Three major workshops were also organised by the consortium, including a final launch event at the Victoria&Albert Museum in London in April 2018 ('Hearing Futures', attended by more than 100 participants, and overbooked within a few days from the moment in which the invitation was sent). A detailed list of dissemination and societal engagement activities can be found in the *D5.4 Dissemination and Communication Report (M36)*, available online at <http://3d-tune-in.eu/Deliverables>).

Despite the official end of the project in April 2018, the consortium is now moving in several directions aiming to carry forward the activities carried out during the project, further exploit the project outcomes and maximise future impact:

- <http://www.hearingamestudio.com/>
- Collaborations between the 3DTI academic partners on further developments and exploitation of the 3DTI Toolkit, including users such as:
 - Weizmann Institute of Science, Department of Neurobiology
 - Georgia Tech
 - University of Castilla – La Mancha
 - AmpAmsterdam
 - Video Art (Blanca Montalvo)
 - University College London
 - Tel-Aviv University
- <https://www.pluggy-project.eu/>

- <https://www.scent-project.eu/>

Address (URL) of the project's public website

<http://3d-tune-in.eu/>

Images attached to the Summary for publication

- Pictures of the first (3DTune-InFirstMeeting.jpg) and last (3DTune-InLastMeeting.jpg) meetings of the consortium
- 3D Tune-In postcard (3DTune-In.jpg)
- 3D Tune-In Toolkit postcard (3DTune-InToolkit.jpg)