Test Plan

Elias William
Rasmus Olofsson
Malva Eveborn
Oskar Ramsberg
Mohammad Alasmi
Adam Roos

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Project Identity

Group E-mail: eliwi204@student.liu.se

Homepage: http://www.isy.liu.se/tsrt10/group

Orderer: Martin Skoglund, ISY/Eriksholm Research Centre
Phone: +46 13 28 18 90
E-mail: martin.skoglund@liu.se

Customer: Sergi Rotger Griful, Oticon
Phone: -
E-mail: segr@eriksholm.com

Supervisor: Johanna Wilroth, ISY
Phone: +46 13-28 28 05
E-mail: johanna.wilroth@liu.se

Course Responsible: Daniel Axehill & Gustaf Hendeby
Phone: +46 013-28 40 42 & +46 13-28 58 15
E-mail: daniel.axehill@liu.se & gustaf.hendeby@liu.se

Participants of the group

Name	**Responsible**	**E-mail**
Elias William	Project Leader (PL)	eliwi204@student.liu.se
Rasmus Olofsson	Responsible for software (SW)	rosol028@student.liu.se
Malva Eveborn	Responsible for documentation (DOC)	malev556@student.liu.se
Oskar Ramsberg	Responsible for design (DES)	oskra262@student.liu.se
Mohammad Alasmi	Responsible for hardware (HW)	mohal555@student.liu.se
Adam Roos	Responsible for testing (TEST)	adaro336@student.liu.se

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Oticon
eliwi204@student.liu.se

DOCUMENT HISTORY

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0.1	2023-10-04	First draft.	EW, MA	
0.2	2023-10-08	Second draft.	EW, MA	AR
0.3	2023-11-09	Third draft.	EW, OR	MA
1.0	2023-11-24	First version.	EW, OR	AR

eliwi204@student.liu.se

1 HEARING AIDS

1.1 Hardware

Test	Requirement	Description
1	1	Test with a voltometer that, when a battery is inserted in the battery holder, there is a voltage over the circuit. Successful test gives between 0.7 V to 1.5 V.
2	1	Test the diode when a battery is inserted in the battery holder. Successful if diode is lit.

1.2 Sound source tracking

Test	Requirement	Description
3	2	Test the automatic speech recognition (ASR) in a room with a speaker playing white noise for 10 s then switching to playing human speech. Successful if the ASR is not activated during the white noise and is activated within 3 s from the start of the speech.
4	3, 4	Test the localization of the direction and position estimate of a stationary sound source (human voice) in a otherwise quite environment when the position of the sound is known and between 1 and 5 m from the user. This should be done for 7 positions where 4 of them are placed with a distance of exactly 1 and 5 m respectively and 2 of these are at the same direction from the stationary user. Successful if: • the direction of the source estimate is within 10 degrees to each side of the ground truth direction. • the position of the source estimate is within 0.5 m of the ground truth position.
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Test	Requirement	Description
5	5, 6	Test the tracking of the direction and position estimate of a moving sound source (human voice) in a otherwise quite environment when the path of the sound is known (from Visionen Qualisys) and between 1 and 5 m from the user. This should be done for 5 paths where one of them are moving at a constant radius from the user, one in a straight line globally and one at a constant direction from the user. Successful if: • the direction of the source estimate is within 10 degrees to each side of the ground truth direction for all estimates. • the position of the source estimate is within 0.5 m of the ground truth position for all estimates.
6	7	Perform tests 4 and 5 with mulitple sound sources simultanously.

1.3 Noise reduction

Test	Requirement	Description
7	8	Test the monaural beamformer by placing one static sound source (pure tone) 2 m in front of a static user and one static sound source (pure tone with different frequency and same power/amplification) in the complete opposite direction of the first source. The beamformer should point directly towards the frontal source. Successful if SNR improvement after processing between the sources are over 5dB.
8	9, 10	Test the binaural beamformer by placing two static sound sources (human speech) at a distance of 2 m from the static user, 60 degrees apart in the frontal direction. The beamformer should point directly to one of the sources. Successful if: • The SNR improvement is atleast 5dB when using one microphone from each hearing aid. • The SNR improvement is atleast 7dB when using both microphone from each hearing aid.
9	11	Test the SINR using only one microphone on one hearing aid by playing two different human voices at 1 m from the microphone separated by 30 degrees. Successful if SINR improvement is at least 7dB.

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Test	Requirement	Description
10	12	Test the speech recognition in a noisy environment by placing two sound sources at a distance of 3 meters from the user, 70 degrees apart where one of the sources produces white noise and the other human speech. The SNR should be 10 dB. Successful if speech can be recognized.
11	13	Test the band-pass filter by inspecting the frequency spectrum of a white noise signal before and after applying the filter. Successful if cut off frequencies are consistent with the set frequencies of the GUI.
12	14	Test PTA amplification by visual inspection of the spectrum of the input and output.
13	15	Test compression by playback audio and also visually inspecting the spectrum of the output signal.

2 G3

2.1 Face detection and tracking

Test	Requirement	Description
14	16, 18, 19	Test face detection and tracking by capturing 3 videos of a face moving with a maximum speed of 100 pixels/s in the image plane, within 1 to 5 meters from the static user, with the camera of the glasses for 10 seconds. Each video captures a different face. Since camera fps is 25, each video should be 250 frames. Successful if: • At least 225 detected faces in each video (excluding false detections) • Minimum 5 disassociations for the tracking in each video
15	17, 21	Test detection placement by inference on the kaggle face detection dataset [**?**], (dataset of facial recognition), and computing IoU with the ground truth annotations. Successful if IoU is at least 0.5 on average.
16	20	Test tracking with user orientation change by capuring a 10 second video with a static face at 2 m and the user is turning their head 180 degrees during the video. Successful if face is tracked as required in test 14.
17	21	Test multiple faces with static user by capturing a video according to test 14 with 3 faces. Successful if same accomplishments as in test 14 is achieved.

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Test	Requirement	Description
18	21	Test multiple faces with moving user by capturing a video according to test 16 with 3 faces. Successful if same accomplishments as in test 14 is achieved.

2.2 Depth estimation

Test	Requirement	Description
19	22	Test face depth estimation by capturing 5 images of one face each from the camera of the user. The faces have known depths where two of them are at the border cases 1 and 5 m. The other 3 are in between 1 and 5 m. Successful if absolute value of the depth estimate error is less than 30 % ground truth depth.
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2.3 Eye-tracking

Test	Requirement	Description
21	23	Test the eye tracking by asking the user to concentrate their sight on an object in distance. The test is successful if by connecting the output from the glasses it appears at a point where the user is concentrating their sight.
22	24, 25	Test the eye tracking position estimation by capturing 10 frames of a face with the camera and the user looking at the nose of the face. The face position is known and should be between 1 and 5 m from the user. Annotate manually the position in the image plane where the nose is. Successful if: • direction estimate is within 10 degrees of ground thruth. • the 3D position is within 0.5 m from ground truth.

2.4 Orientation

Test	Requirement	Description
23	26 - 28	Place the G3 glasses on a flat table in a stationary position for 10 seconds and save the measurements to calculate the bias for the gyroscope and compensate for it, then move the glasses randomly for 3 seconds and place them back in the same position. Successful if the yaw, pitch and roll angles have an error within 20 degrees for each angle.
24	26 - 28	Place the G3 glasses on the head of an user. Stand still for 10 seconds and save the measurements to calculate the bias for the gyroscope and compensate for it. Rotate the body 90° in the horizontal plane while holding the head still and then stand stand at the new position for 10 seconds. Repeat the 90° rotation three times. Success full if the yaw angle has an error within 20 degrees.

3 ENTIRE SYSTEM

3.1 Relative orientation

Test	Requirement	Description
25	30	Test sensitivity by having two users with different head shapes than the modeled one try the HA and G3 glasses. Measure the differences of the head shapes and test how the beamforming with eye-tracking is affected.
26	31	Test the relative head shape function by testing the beamforming with eye-tracker for 3 different head shapes, modeling each head by their own.

3.2 Sound source tracking and amplification

Test	Requirement	Description
27	32	Test the computation on recorded data by recording a dataset from both the glasses and the hearing aids (Camera, eyetracker, microphones on HA, possibly IMU in moving user scenario) as in tests 29 - 36 and then be able to use this dataset to perform the computations in hindsight instead of real-time.

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Test	Requirement	Description
28	33, 49 - 51	Test the real-time computations by performing tests 29 - 36 in real-time. Successful if all performance requirments (49 - 51) are fulfilled and also the requirment of the current test is fulfilled.
29	34	Test the sound source tracking with eye-tracker functionality by placing two sound sources (human voice) at an angle of 70 degrees at a distance of 5 m from the static user. The user will then visually attend one of them and the sound source tracker should track this sound source object. Successful if the tracker indicates that the tracked sound source is the one visually attended to.
30	35A	Test the beamforming module for static user and sound source by placing a static user and two static sound sources (human voice) at a distance of 2 meters from the user, 60 degrees apart. Visually attend one of the sound sources. Successful if SNR improvement at the output is atleast 7 dB and the signal is the sound source that the user visually attends to.
31	35B	Test the beamforming module for static user and moving sound source by placing a static user and one moving sound source (human voice) in the frontal direction at a distance of 2 meters from the user. The user should focus their gaze on a point straight ahead of the user. The sound source should pass the gaze point during the movements and the output signal for each angle should be accessed. To get accurate angle of sound source Qualisys should be used. Successful if SNR difference from the peak output amplitude to the amplitude 60 degrees from the peak is -7 dB.
32	35B	Test the real-time performance of the beamforming module by repeating test 31 but always visually attending the moving sound source. Successful if the output should always amplifies the sound of the source.
33	35C	Test the beamforming module for moving user and static sound source by placing a user and two static sound sources (human voice) at a distance of 2 meters from the user, 60 degrees apart. Visually attend one of the sound sources and also turn head as to point to the person attended to. Successful if SNR improvement at the output is atleast 7 dB and the signal is the sound source that the user visually attends and turned to.
34	35C	Test the beamforming module for moving user and static sound source by placing a user and one static sound sources (human voice) 2 meters from the user in the frontal direction. Visually attend the sound source and also turn head from side to side still visually gazing the sound source. Successful if sound source is amplified at all times.
35	35D	Test the beamforming module for moving user and sound source by the same setup as in test 31 but the user visually attending the source at all times and turning their head simultanously. Successful if sound from source is amplified at all times.

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Test	Requirement	Description
36	36	Test track and camera alignment by placing a sound source at a distance of 5 m from a static user and tracking it with the HA. Then also using the face detection in the camera of the glasses to detect the sound source and estimating the angle to it from the user. This can later be used for calibration. Successful if estimated directions are within 20 degrees of eachother.

4 GUI

Test	Requirement	Description
37	37-40,42-44	Connect the hearing aids to GUI and be able to: • turn on and off the amplification • display and change the intensity of amplifying • record sound for at least 10 seconds before it is amplified and listen to it. • Listen to the amplified sound that is coming is from the hearing aids.
38	41	Connect the G3 glasses to GUI and be able to record data for at least 10 seconds.
39	45-48	The output data from the modules are implemented, processed, and stored in the GUI. Then the GUI displays the estimated speaker's position relative to the user as well as the measured ground truth. In addition, the GUI stores all the data from both inputs (G3 glasses and hearing aids).

5 PERFORMANCE TESTS

Test	Requirement	Description
40	49	Measure the time delay between the input from the hearing aids and the audio output during the various tests explained earlier. Successful if the delay is within 50 ms.
41	50	Measure how many data samples the hearing aids produce per 1 min. Successful if the sampling frequency is equal or higher than 8000 Hz
42	51	Measure how many data samples the G3 produce. Successful if the sampling frequency is at least 5 Hz in online processing