AMBIENT ASSISTED LIVING, AAL

JOINT PROGRAMME

ICT-BASED SOLUTIONS FOR ADVANCEMENT OF OLDER PERSONS' INDEPENDENCE AND PARTICIPATION IN THE "SELF-SERVE SOCIETY"

D 4.3

Mobile platform: technical performance evaluation

Project acronym:	**ENTRANCE**
Project full title:	**ENabling elderly people TRAvel and iNternet acCEss**
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TERMINOLOGY & ABBREVIATIONS

To assure coherent terminology and abbreviations across all documents inside the project, the specific terminology and abbreviations for this deliverable should be written here.

aGPS ....assisted GPS

E.g. ....Example given

EDGE ....Enhanced Data rates for GSM Evolution

GLONASS ....Global Navigation Satellite System

GPRS ....General packet radio service

GPS ....Global Positioning System

GSM..................................Group Spécial Mobile (Global System for Mobile Communications)

HSPA.................................High Speed Packet Access

IPS ....Indoor Positioning System

LBS...................................Location Based Services

LTE ....Long Term Evolution

TTFF.................................Time To First Fix

1 EXECUTIVE SUMMARY

1.1 Link with the objectives of the project

This deliverable presents an evaluation of the technical performances of the mobile platform for indoor and outdoor navigation. It was prepared by the technical partners having developed the mobile platform. The performance evaluation concerns the localisation both outdoor and indoor, the mobile connectivity and the wristband.

1.2 State of the art

The technical performance of the mobile platform was tested in various settings. The overall expectation was fulfilled and is in accordance with current technical standards. The influencing factors of the mobile internet connection (e.g. distance to cell tower or building structure) will also influence the quality and experience with the mobile platform. The internet connection will be a key factor, because the indoor position will be calculated on a server.

2 MOBILE PLATFORM

The mobile platform performance evaluation refers to the localisation (indoor and outdoor), the mobile connectivity, the navigation and the vibrotactile interface. For a seamless navigation it is important that the localisation is fast. The actual position of a user holding the smartphone in front of him is needed to give navigation feedback. Hence, the document has the following structure: indoor localisation, outdoor localisation, mobile connectivity and vibrotactile wristband interactions.

2.1 Outdoor Localisation

The outdoor localisation is based on the Global Positioning System (GPS). GPS is a space-based satellite navigation system that provides location and time information. Four or more GPS satellites cover each global position (NAPA 1995) and are used for military, civil and commercial services around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver. Other available or upcoming satellite systems are GLONASS (Global Navigation Satellite System) from Russia, COMPASS from China or Galileo from the European Union.

Figure 1: GPS for outdoor localisation

2.1.1 Overview

At least a GPS receiver can be found in smartphones to localise a person and provide Location-Based Services (LBS) or navigation opportunities. Some currently available smartphones also support GLONASS to get a higher reliability of the local position. Basic GPS measurements yield only a position. However, most GPS units can automatically derive velocity and direction of movement from two or more position measurements.

For the mobile platform, we deal with standard devices, so there will be differences in the performance and accuracy of the outdoor localisation. These differences will depend on the GPS-chip used inside the smartphone. The location will also have a big impact on the accuracy and the visibility of the satellites. The GPS receiver uses a geometric method called trilateration, based on intersecting spheres, to find the position of the GPS device. Additional information like speed, acceleration, altitude can be determined.

2.1.2 Performance check

We tested various smartphones to check how long it will take to get a position, as well as the resulting accuracy, while walking outside. There are differences between a cold time to first fix (TTFF), warm TTFF and hot TTFF. If a device is turned off for a long period of time or has been transported for a long distance since it was turned on, it takes longer to acquire the ephemeris data and get a time to first fix (TTFF). The specified time for a cold TTFF for smartphones various between 20 and 60 seconds. Starting outside in an unknown environment can thus be very long. A warm TTFF is the time the GPS receiver needs to acquire position fix with no ephemeris data available. This mostly takes less than a minute and starts with estimation and will be more accurate within time. A hot TTFF assumes the receiver has a valid position from the satellites in view. Many smartphones reduce the TTFF by using assisted GPS (aGPS) and download the ephemeris data of an internet connection, which is much faster than the satellite data. The hot TTFF is often on the order of 1-5 seconds.

2.1.3 Conclusion

Depending on the situation in which people use the mobile platform, they can influence the outdoor localisation time by using the mobile platform continuously. To address the end-user and standard hardware we have to deal with the variety of smartphones with the integrated GPS receiver.

2.2 Indoor Localisation

An indoor positioning system (IPS) is a network of devices used to wirelessly locate objects or people inside a building (CFLSWC 2011). There is currently no de facto standard for an IPS systems design, so deployment has been slow. Nevertheless, there are several commercial systems on the market. For the mobile platform we use a WiFi-fingerprint solution. Besides fingerprinting, other techniques can be used (e.g. magnetic field or light frequencies).

2.2.1 Overview

WiFi-fingerprint for IPS is used where GPS is inadequate due to various causes including multipath and signal blockage indoors. The localization technique used for positioning with wireless access points is based on measuring the intensity of the received signal strength (RSS) and the method of "fingerprinting" (ChKo 2002). The accuracy depends on the number of positions that have been collected and entered into a database. The possible signal fluctuations that may occur (e.g. people count) can increase errors and inaccuracies in the path of the user. To minimize fluctuations in the received signal, there are certain techniques that can be applied to filter the noise.

2.2.2 Performance check

The indoor position system was tested in two regions, i.e. in Hungary in GFTH office and in Germany in GeoMobile office.

The measurements of GFTH can be found in ANNEX D

In GeoMobile office, the fingerprints were collected at relevant points (see Figure 2 – left) and we had fixed measurement points (see Figure 2 – right). At each measurement point we collected the position three times. The details and results of the measurements while moving around can be viewed in the Annex A. Measurements at fixed points in the office can be found in Annex B.

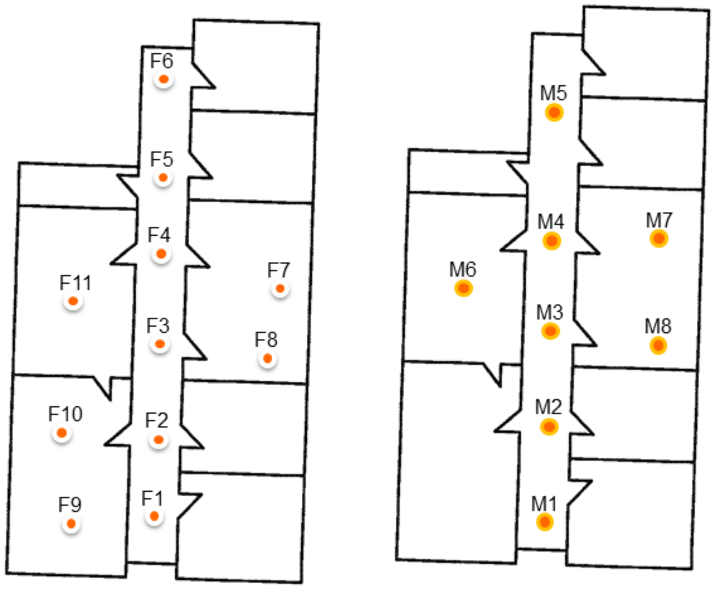

Figure 2: Fingerprint collection (left) – measurement points (right)

After we had done the first measurements, the service for the position calculation was readjusted on the server to provide a better localisation. After it was improved, it currently delivers more accurate positions with some jerky leaps and a delay. When a person is running through a building, the delay is obvious in contrast to normal movements.

Figure 3: Measurement of the last test

2.2.3 Conclusion

The IPS provides a position within the building with an accuracy of up to 5 meters. Sometimes there are jerky leaps, while moving around. Due to the system setting and experiences with other solutions this can be used inside a complex building for orientation. Its weak points are interleave and small areas with tight corridors and doors.

The point measurements show that in some cases the location is good (compare point measurement 4 in Annex B). One reason could be the nearly identical position of the measurement point with the fingerprint collection point. At another point (compare point measurement 5 in Annex B), it is totally different.

The IPS needs sometimes a reset to continuously provide a position. This open issue will be covered and fixed with an update. But overall, it **provides a possible overview for orientation in lab studies**. The **test on-site** in a shopping mall, where many people are influencing the surrounding, **will show if the position is reliable and good enough for orientation or not**.

2.3 Mobile connectivity

Mobile connectivity is highly dependent on the local surrounding. Mobile connectivity offers wireless internet access through a portable modem like a mobile phone, USB wireless modem, tablet or other mobile devices. The first wireless internet access uses the second generation (2G) of mobile phone technology. Higher speeds became available as part of the third (3G) and fourth (4G) generations. In 2011, 90% of the world's population lived in areas with 2G coverage, while 45% lived in areas with 2G and 3G coverage.

2.3.1 Overview

Mobile connectivity is provided via the mobile network providers. Different technologies of the second generation (2G), third generation (3G) and fourth generation (4G) are for example GPRS, EDGE, HSPA or LTE (Sauter 2011).

Technology \ Speed	Down	Up
GSM GPRS	56 to 115 Kbit/s	56 to 115 Kbit/s
GSM EDGE	Up to 237 Kbit/s	Up to 237 Kbit/s
UMTS HSPA	14.4 Mbit/s	5,8 Mbit/s
HSPA+	21-672 Mbit/s	5,8 to 168 Mbit/s
LTE	100 to 300 Mbit/s	50-75 Mbit/s

Table 1: EU27 NGA broadband coverage per country at the end of 2012 (EC2013)

GPRS (General packet radio service) is part of the 2G. It provides moderate-speed data transfer. It is highly available inside the mobile network because it extends the GSM Packet circuit switched data capabilities.

EDGE (Enhanced Data rates for GSM Evolution) improves the data transmission inside GSM networks and was introduced in 2003. EDGE is considered a pre 3G technology and delivers higher bit-rates per radio channel, resulting in a threefold increase of the GPRS connection.

HSPA (High Speed Packet Access) as part of the UMTS has achieved a high degree of coverage across the EU in a relatively short time. Eighteen countries were above the European Union average of 96.3% and none were below 85% (EC 2013). HSPA+ enhances the widely used technology based on 3G networks with higher speeds. HSPA is supported by nearly all of the current smartphones.

LTE (Long Term Evolution) coverage increased rapidly in 2012, with coverage growing by 18 percentage points (EU 2013). Averaged across the European Union, LTE coverage was 27.0%. Many countries were undertaking working trials and had already granted licences for LTE spectrum. Coverage is again expected to increase rapidly during within next years. Currently there are only few devices supporting LTE.

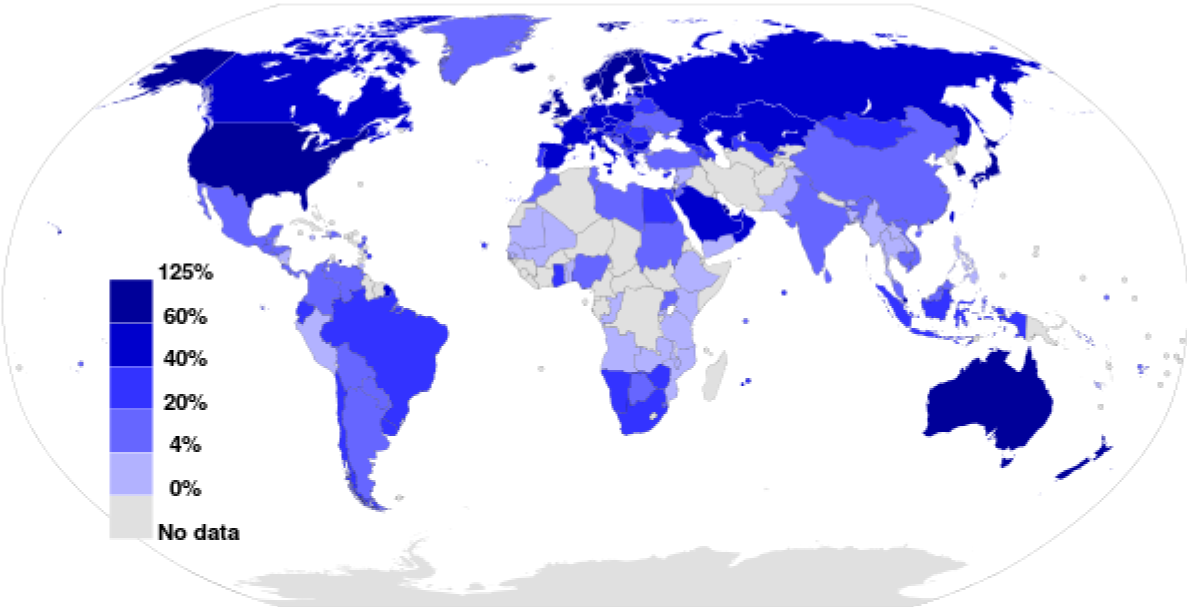

Figure 4: Mobile broadband internet subscriptions in 2012 (ITU 2013)

2.3.2 Performance check

As mentioned above, in 2011, 90% of the world's population lived in areas with 2G coverage, while 45% lived in areas with 2G and 3G coverage, and 5% lived in areas with 4G coverage. By 2017 more than 90% of the world's population is expected to have 2G coverage, 85% is expected to have 3G coverage, and 50% will have 4G coverage (Ericsson 2012). The percentage across Europe will be higher (EU 2013).

A barrier to mobile broadband use is the coverage provided by the mobile phone networks and the quality (no or limited services). Customers will not always be able to achieve the speeds advertised due to mobile data coverage limitations including distance to the cell tower. In addition, there are issues with connectivity, network capacity, application quality, and mobile network operators' overall inexperience with data traffic. Peak speeds experienced by users are also often limited by the capabilities of their smartphone or mobile device (Ericsson 2012).

Various influencing factors exist for the bandwidth of the mobile internet connection. In the lab we cannot simulate all of them, but we can simulate the bandwidth itself. Factors influencing the connectivity are:

- Indoor vs. Outdoor
- Cellar vs. Roof
- Distance to cell tower
- Count of walls
- Building construction
- Simultaneous user

The performance of the mobile connectivity is checked within a lab environment using a special router, which can be configured to simulate various bandwidths. The bandwidth used represents the maximum bandwidth of the mobile networks (see Table 1).

Depending on the mobile connectivity, we tried various speed limitations for the mobile platform to download the data from the server. We used a broadband connectivity at the office and the mobile connection of the O2 network (One major mobile network provider). Alternatives like Telekom, Vodafone or E-Plus in Germany were not tested. The following table shows the average of the measurements using the mobile platform. We have to take into account that all data are cached once they are downloaded. This allows a fast usage of the app. The Table 2 list the average time to download the activity view from the server. Take a closer look in the Annex C to read the details of the measurements.

Connection type	First load of an activity (in average)	Revisit of an activity (in average)
WiFi in the office	3,23	<1
HSPA	6,37	1,03
EDGE	11,7	1,6
GPRS	42,7	2,4

Table 2: Time measurements of loading data from the server for the mobile platform

2.3.3 Conclusion

However, the coverage of mobile internet across Europe represents the mobile operators' own reported coverage areas in most cases, which use varying standards as far as actual performance is concerned. Providing at least 1Mbps download speed, coverage areas are lower. As users know, actual performance can vary inside coverage areas due to influencing factors (e.g. indoors vs. outdoors, hills vs valleys).

According to the results of the connection it can be stated, that at least the initializing of the mobile platform should be done at least using HSPA. One the initializing is made, the data load correspond to the user experiences. Loading tiles of the map with a slow mobile internet connection can take very long, so that changes between zoom levels can take longer than expected.

3 OVERALL CONCLUSION ON LOCALISATION

Overall we found out that we have bottle necks. Two major bottle necks are the indoor localisation and the mobile connectivity. The indoor localisation is in general not 100% exact , but in combination with a map view it is helpful for orientation. However, there might be situations, where the indoor localisation may muddle users while walking inside a complex building. One example might be the toilets, because they are reached with a narrow long corridor in the background of the building. In that area the position can strongly vary.

In combination with a slow mobile connectivity, the indoor localisation becomes harder, because the position calculation is done on the server. Even if the data load is not high (just a few characters), the data transportation over a slow connection might be too long. The person will move ahead but the position when not updated and will be gradually outdated. In this situation, we can only estimate an additional hint for the user, that the localisation takes time because of a slow internet connection.

Other possibilities are estimations of the position, because the user is walking forward into one direction. In combination with the inertial sensors of the smartphone, this will open the possibility to calculate the position after the internet connection is lost.

The mobile platform will perform within the current technical parameters. The penetration of faster mobile internet connection, for example with LTE ,will rise within time. Also additional services like free WiFi are provided more and more at complex buildings (e.g. shopping malls, airports, etc.). However, not every complex building will provide free WiFi (e.g. hospital) and in this case other factors have to be checked to use the mobile platform inside that building.

4 DESIGN AND TECHNICAL PERFORMANCE OF THE VIBROTACTILE WRISTBAND: MECHANICAL COMPONENTS AND ELECTRONICS

4.1 Wristband improvements

The first version of the vibrotactile wristband included 8 vibrators. A vibrator is made of a vibration motor inside a small plastic box. They were placed around the wrist thanks to hook-and-loop fastener that allowed adjustment of the position for each of them. The control and power electronics were in a box outside of the wristband (see Figure 5).

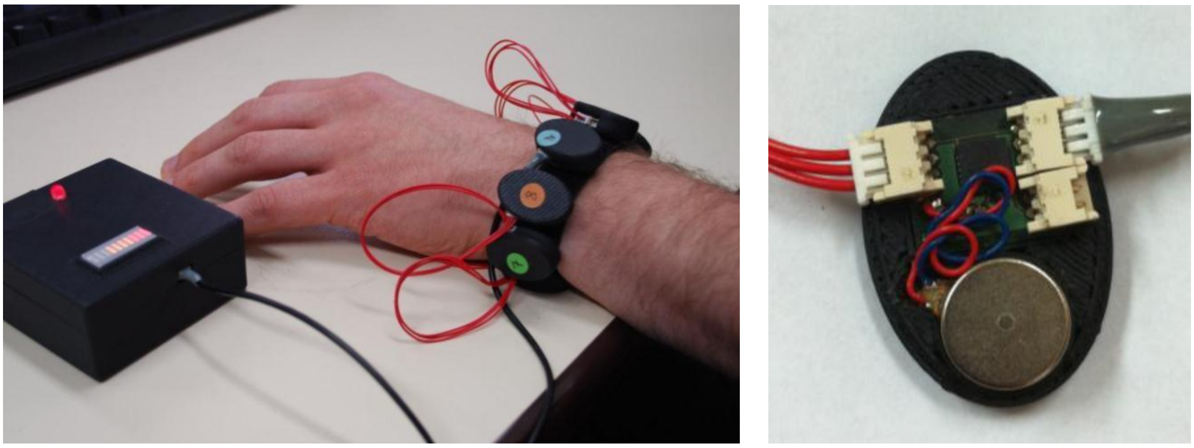

Figure 5: 1st prototype of the haptic wristband and its electronics (left) and a single vibrator (right)

Informal user evaluations showed that this bracelet was too rigid. As a result, a second version of the wristband, similar to the first one, was developed. The improvement focused on the vibrators integration. The vibration motors were encapsulated in silicone. The shape was thus optimized to avoid vibration transmission between the motors while providing a wristband casted in one piece (see Figure 6).

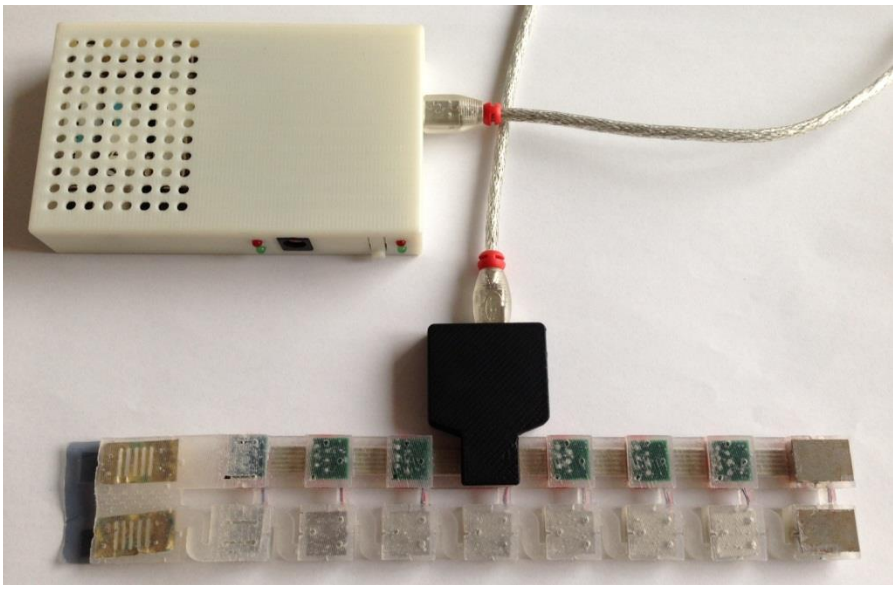

Figure 6: 2nd prototype wrapped in silicone

The main inconvenient of the two first versions were that the wristband could not be used independently. It had to be controlled and powered by electronics outside the device. This issue was also noted by the reviewers during the mid-term review and a number of users when testing vibrotactile patterns. In order to improve the usability and the acceptability of the device and to reduce its power consumption and the electronic complexity, the number of vibrators was reduced from 8 to 3. This modification allowed building a fully-integrated wristband.

The third version thus includes 3 vibration motors: the first one in a small housing with the electronics and the battery, and the two others on each side of a watch bracelet (see Figure 7).

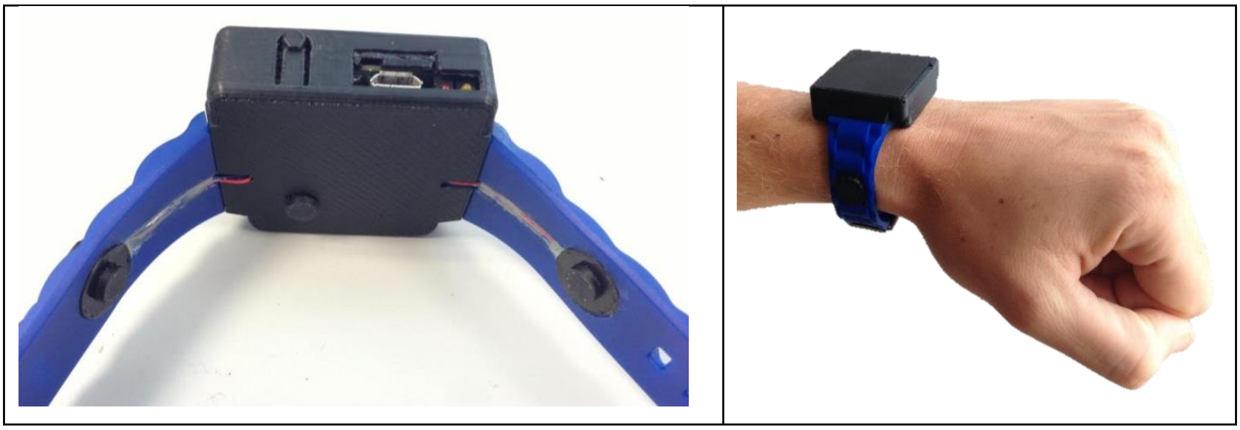

Figure 7: 3rd prototype with 3 vibrators

Since the joints between the bracelet or the housing and the vibrators are rigid, the vibration is transmitted throughout the wristband. The fourth and last version suppresses the vibration spreading. Each vibration motor is glued on a textile membrane that isolates it from the rest of the device. Then the vibration is confined in one point and the vibrotactile message is perceived better (see Figure 8).

Figure 8: Flexible membranes of the 4th version (left) and 3 prototypes (right)

Now the main problem, pointed during the user studies in the lab, lies in the bracelet stiffness. In fact, the watch bracelet used in prototypes 3 and 4 is too rigid and does not allow a good contact between the user's skin and the vibrators. **CEA is currently working on a new design with flexible links which will offer more flexibility to the user**.

As mentioned above, in order to facilitate its use in mobility and to improve its acceptability, the vibrotactile wristband was simplified and miniaturized. Thus, the system now consists of one single box worn on the wrist (see Figure 8). The previous version was composed of housing and an additional box, which contained a "supervisor ", and was attached to the user's arm and connected by a cable as shown in Figure 12.

The following parts describe the new design in more details.

Figure 9, Figure 10, Figure 11 and Figure 12 present the constitution of the first prototype which consisted of two parts (see Figure 5).

Figure 9 and Figure 10 show the functions that have been removed in order to save space. The battery technology has also been changed (see further for more details). The same is valid for the battery management system. A number of electronic functions to stabilize the power avoiding variations in battery voltage have also been suppressed. The reduction from 8 vibrators to only 3 resulted in a significant reduction of the number of components as well as of the power required. Thus, the size of the components responsible for the provision of electrical power was also reduced.

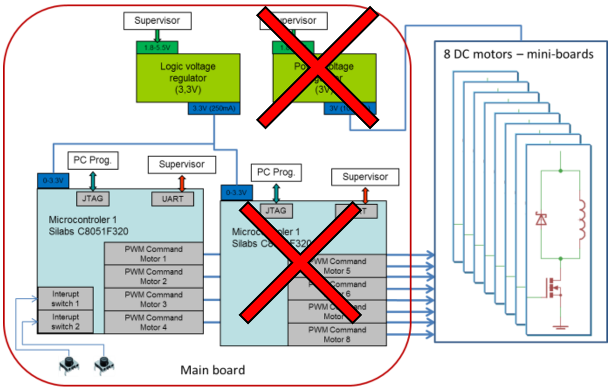

Figure 9: Electronic scheme for the vibrating wristband

(1st version)

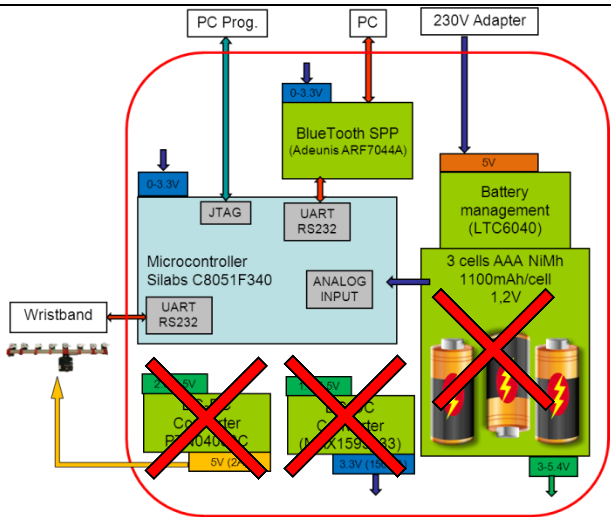

Figure 10: Electronic scheme for the supervisor

(2nd version)

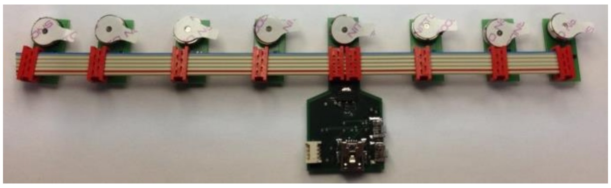

Figure 11: Wristband: (1st prototype)

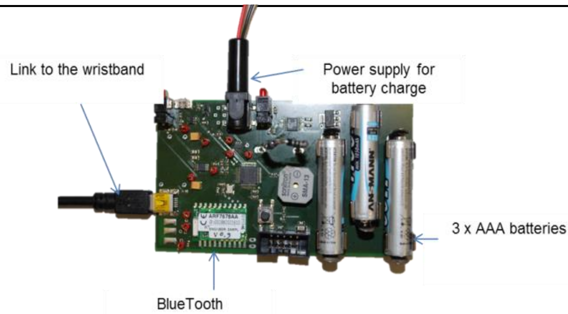

Figure 12: Supervisor: (First prototype)

The result of this optimization is illustrated in Figure 13 and Figure 14. Figure 13 shows the functional diagram resulting from the merging and the optimization of the two previous designs. It represents one board that can be inserted into a box as big as a standard watch, as shown in Figure 14.

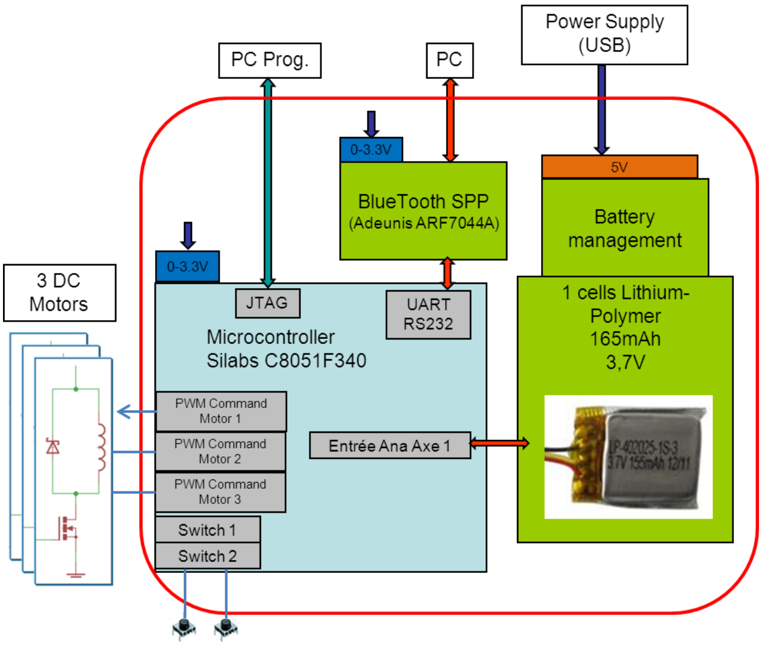

Figure 13: Electronic scheme for the vibrating wristband (2nd version)

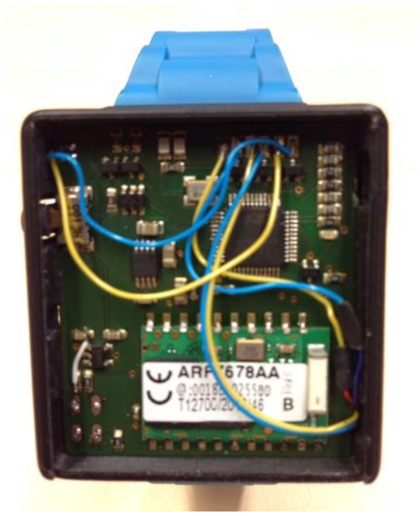

Figure 14: Current version of the wristband

Table 3 provides a summary of the structural and functional changes. By combining the two PCBs and reducing a number of specific functions, the total area of the PCB was divided by 5 and the number of components was divided by 2.5. As a counterpart, it is no longer possible to use the prototype when charging the battery. Moreover, the first version of the electronics included different power regulation stages to suppress vibrotactile variation due to the natural voltage fluctuations of the battery during the discharge process. In this second version of the electronics, as the battery is either fully charged or at the end of its life, the maximum level of vibration actuators can vary.

	First wristband (Supervisor+Wrisband)	**New wristband**	**Gain**
Components	76+53=129	51	/2,5 ☺
PCB size	62,40cm²+12,16cm²=74,56cm²	14cm²	/5,3 ☺
Functions	Large autonomy & fine power regulation =Well adapted for user-study	lightweight but Small autonomy & power unregulated (vibrotactile stimulation could varies following battery level) =Well adapted for low cost product	

Table 3: Structural and functional modifications

4.2 Power consumption

The battery technology underwent also through important modifications. Table 4 compares the energy and the dimensional differences between the first and the second version of the battery. The choice of a Lithium Polymer battery technology enables a reduction in size and weight and a better integration thanks to the rectangular flat battery. However, to fit the volume of a standard watch, the battery life is much lower than in the previous version. Moreover, LiPo technology exhibits problems of stability. Consequently, special precautions were taken as a slow charging setting avoiding overheat and implementation of an algorithm for automatic disconnection for different cases. However, the positive point is the possibility to recharge the battery using a USB connection.

	Prototype with 3 NiMh battery **(1st prototype)** 	**Prototype with LiPo battery** **(2nd prototype)** 	**Gain**
Volume	24090 mm3	1976 mm3	/12 ☺
Weight	90g	4g	/22 ☺
Capacity	2850mAh (3,6V)	165mAh (3,7V)	/17 ☹
Capacity/Volume	0,11 mAh/mm3	0,08mAh/mm3	X 1,3 ☺
Capacity/Weight	31mAh/g	41mAh/g	X 1,3 ☺
Max continuous discharge current	2700mA	310mA	/8
Autonomy	5 hours (power time ratio 50% with 8 vibrators)	1 hour (power time ratio 50% With 3 vibrators)	/5 ☹
Safety	Stable	May be unstable in specification condition	☹

Table 4: Battery modification

4.3 Conclusion

The current version of the electronics complies with the requirements of integration into a lightweight and easier-to-use device. However, the first prototype remains a tool for tactile language development showing better performances in terms of tactile metaphor control and autonomy.

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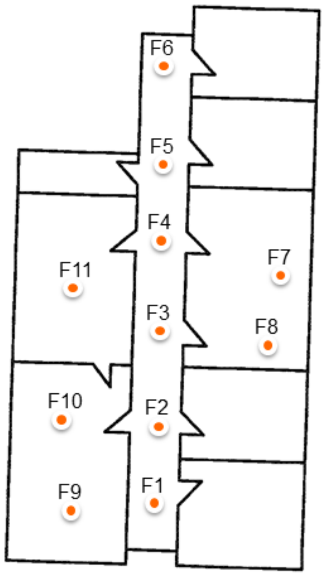
ANNEX A

Here are the tests of movements to specific parts inside the building. 8 Points where selected. Starting from measurement point 1to 8, the position was gathered by moving to Mx collect the first position. Wait for 1 second to get the second position and afterwards wait for another second to get the third position. After the third position is gathered move to the next measurement point.

Fingerprints

GeoMobile

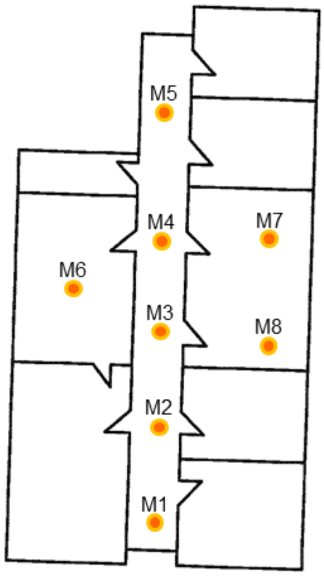
- GM-Floormap
- Bounding Box:
  north: 51.49187202549268
  south: 51.49164489535436
  east: 7.405555677509277
  west: 7.405309833294491
- Imagesize: 867 x 1310



Points for measurement

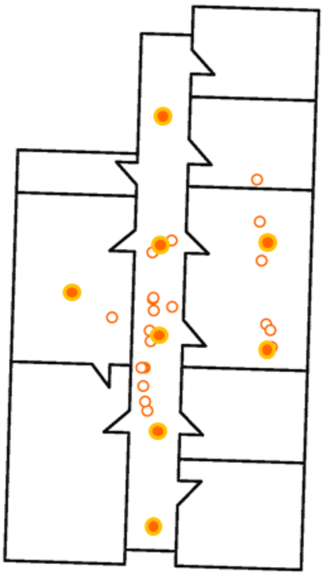
GeoMobile

- Simple measurement at each point
- Save 3 calculated position at each point of measurement
  - 1: when reaching the pos.
  - 2: after 2 sec.
  - 3: after additional 2 sec.
- Measurement with HTC ONE X and Android 4.1.1
- Measure delay in accuracy



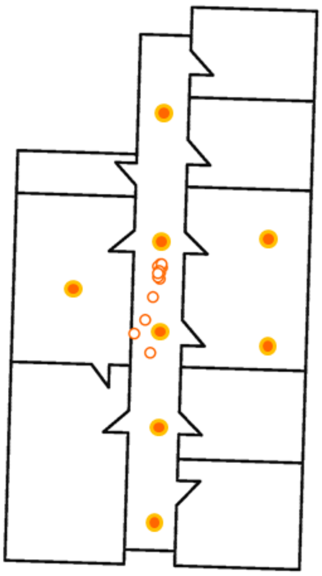
1st Measurement

MP	x1	y1	x2	y2	x3	y3
M1	681	766	680	730	463	677
M2	416	900	416	900	409	888
M3	407	850	409	813	408	809
M4	408	806	416	755	415	730
M5	426	682	417	664	417	645
M6	461	531	410	558	319	692
M7	644	398	654	494	660	577
M8	677	753	677	753	669	709



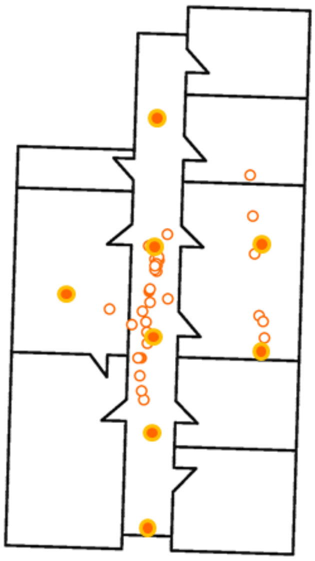
2nd Measurement

MP	x1	y1	x2	y2	x3	y3
M1	418	649	419	777	419	777
M2	389	724	400	701	438	631
M3	440	623	442	614	441	604
M4	441	593	440	581	441	585
M5	443	589	443	589	443	592
M6	444	592	444	592	443	595
M7	444	596	444	592	443	595
M8	443	592	442	591	440	591



Results and implications

- Unexact position
- Strong variance in accuracy
- Delay in position calculation
- Edges are not covered



Next steps

- Collect more fingerprints
- Algorithm improvement

1st Remeasurement

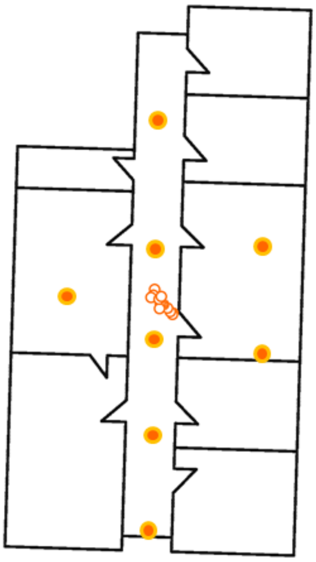
Remeasurement of Fingerprint and Localisation

Fingerprints

- GM-Floormap
- Bounding Box:
  north: 51.49187202549268
  south: 51.49164489535436
  east: 7.405555677509277
  west: 7.405309833294491
- Imagesize: 867 x 1310

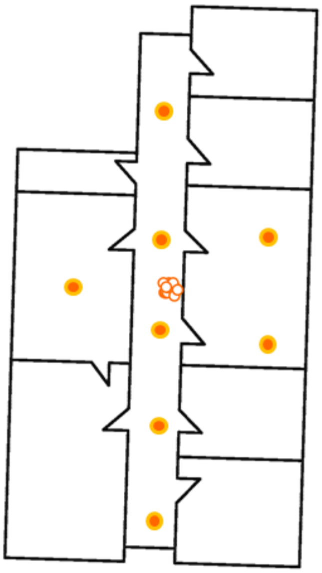
3rd Measurement

MP	x1	y1	x2	y2	x3	y3
M1	477	702	477	702	479	702
M2	476	699	463	698	458	698
M3	448	683	448	685	451	697
M4	451	697	451	697	452	696
M5	447	698	441	691	441	680
M6	442	669	436	666	428	665
M7	423	665	424	667	433	667
M8	442	672	442	672	442	672



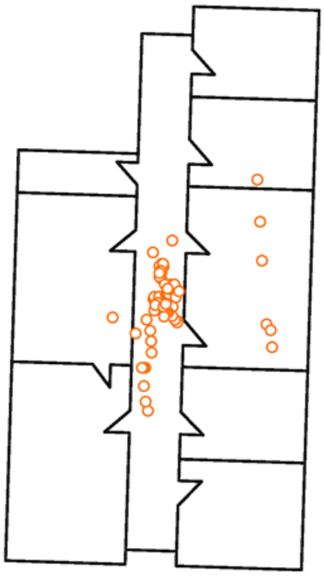
4th Measurement

MP	x1	y1	x2	y2	x3	y3
M1	475	642	475	642	475	642
M2	475	642	475	642	475	642
M3	465	647	466	648	466	648
M4	470	647	470	647	466	648
M5	466	648	466	648	466	648
M6	466	648	466	648	466	648
M7	463	650	460	639	460	637
M8	461	638	461	632	461	631



Overall Measurements

- Centralised Localization
- More Fingerprints does not increase accuracy
- Numerous similar coordinates



Improvements for tools

- Define a bounding box for map
- Delete of measured fingerprints
- Measurements while walking
- Define “no go” areas
- …

2st Remeasurement

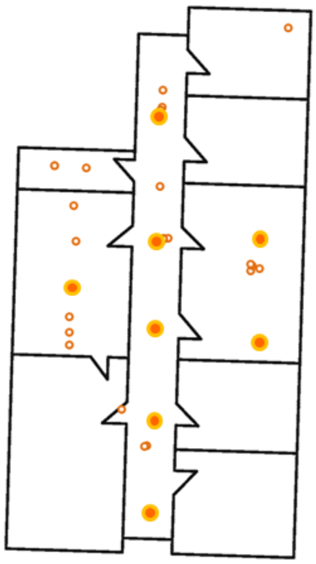
Remeasurement of Fingerprint and Localisation

Fingerprints

- GM-Floormap
- Bounding Box:
  north: 51.49187202549268
  south: 51.49164489535436
  east: 7.405555677509277
  west: 7.405309833294491
- Imagesize: 867 x 1310
- Location service improvements on server

5th Measurement

MP	x1	y1	x2	y2	x3	y3
M1	215	381	420	1006	417	1008
M2	284	385	261	547	364	924
M3	454	248	451	426	246	717
M4	258	468	459	542	459	543
M5	453	256	215	381	457	211
M6	453	255	246	752	246	779
M7	654	613	467	542	673	609
M8	738	70	657	604	655	600



6th Measurement

GeoMobile

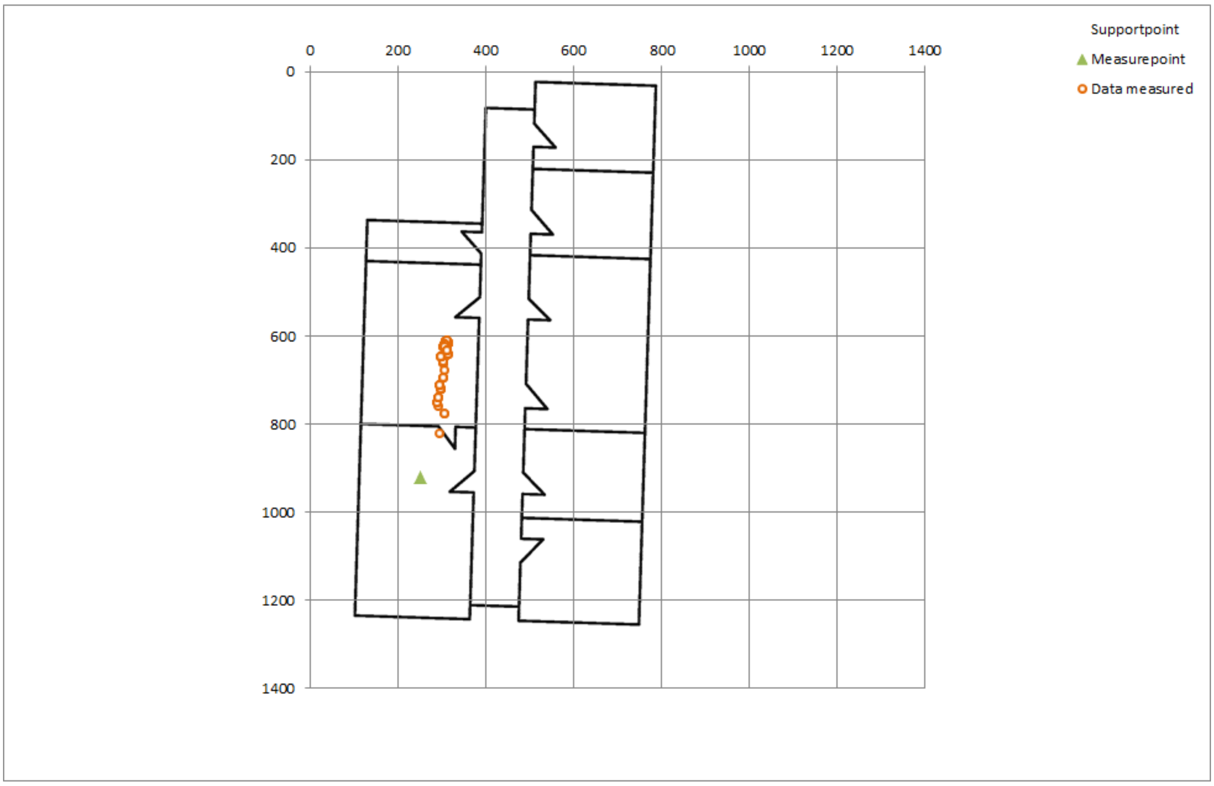
MP	x1	y1	x2	y2	x3	y3
M1	453	956	246	925	266	384
M2	306	377	480	944	243	418
M3	445	575	449	539	451	503
M4	445	596	449	528	482	575
M5	457	346	457	145	457	145
M6	238	495	238	495	242	430
M7	628	538	628	538	628	538
M8	665	771	665	771	665	771

ANNEX B

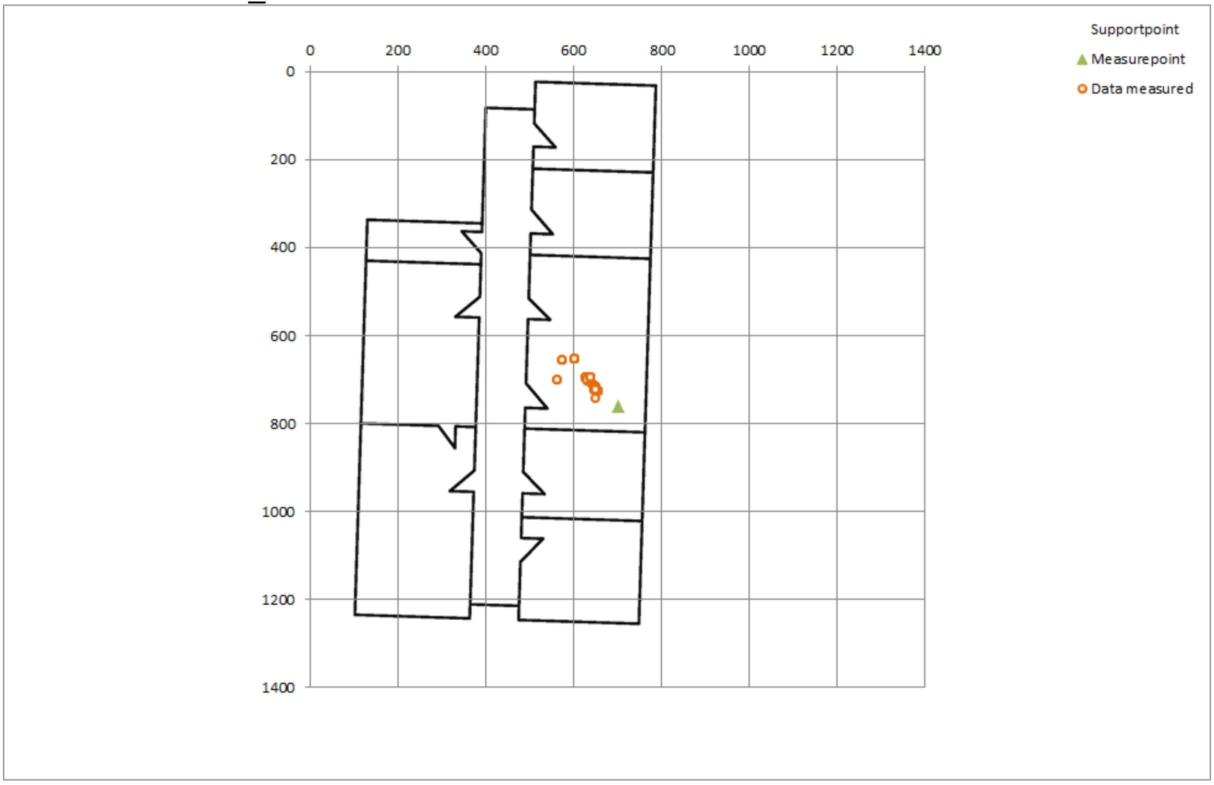
At a specific location inside the building (measurepoint) the position from the IPS was gathered each second. The collected data points are shown in the following figures.

The first and second measurements are based on the first algorithm. The third measurement based on the second version, while the measurement 4 and 5 base on the last server based algorithm.

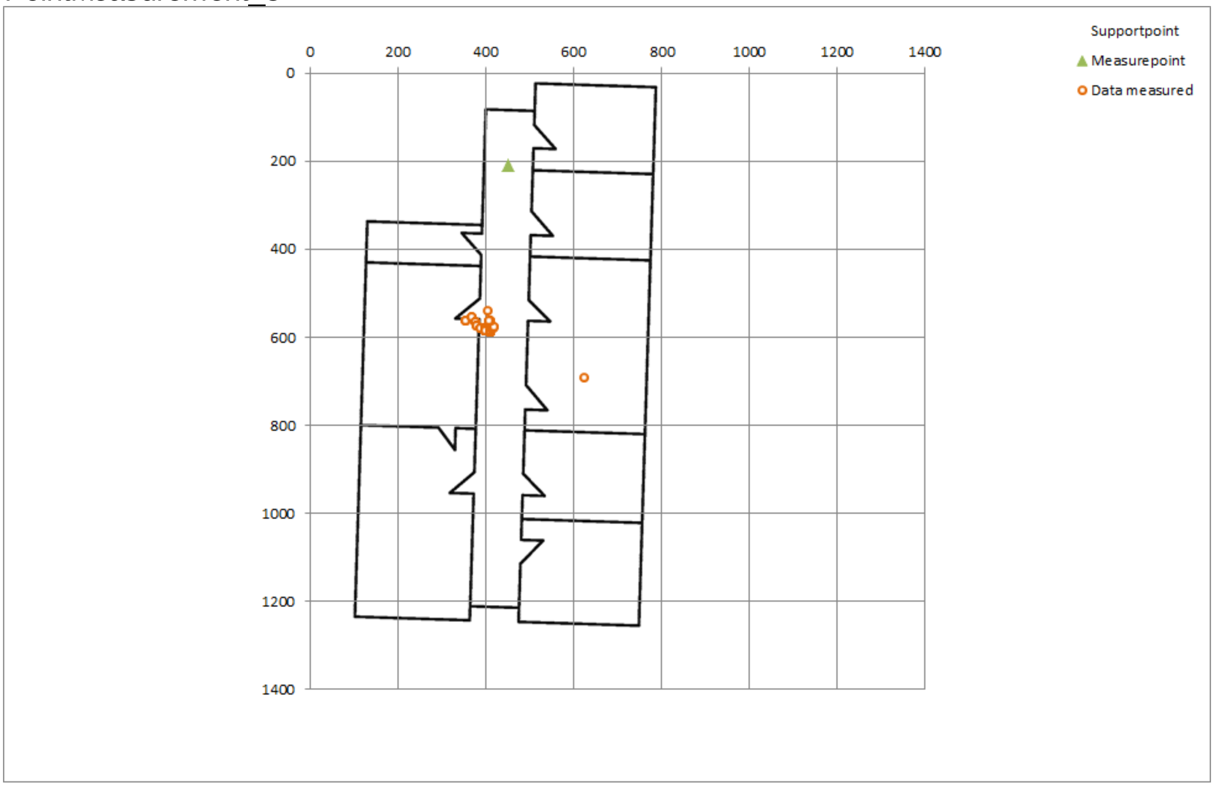
PointMeasurement_1:



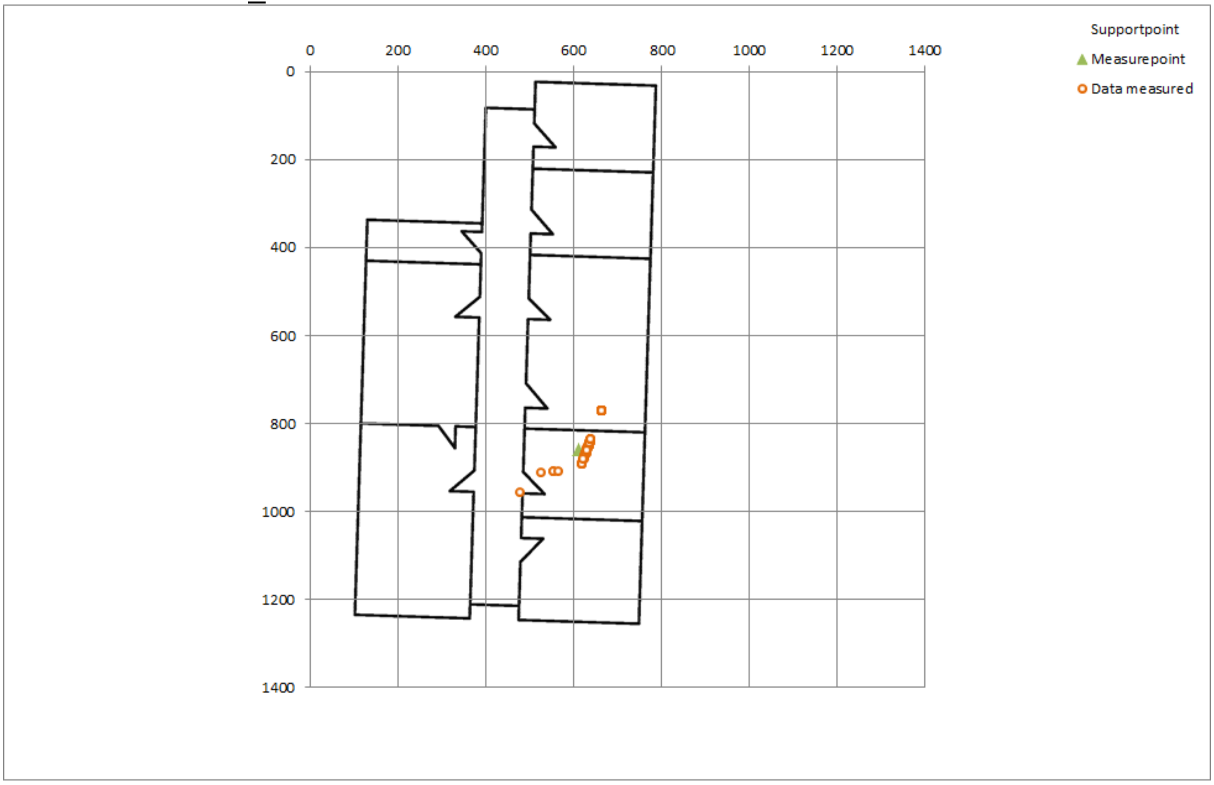
PointMeasurement_2:



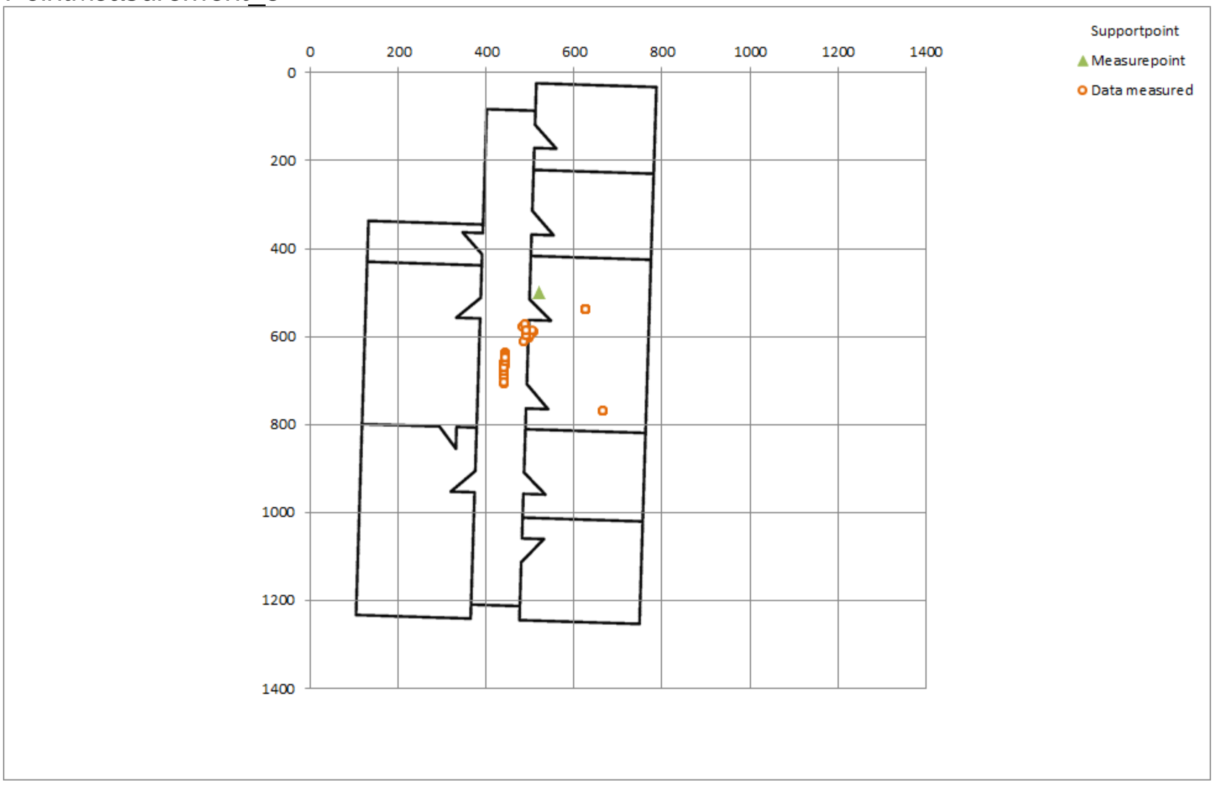
PointMeasurement_3



PointMeasurement_4



PointMeasurement_5



ANNEX C

Measurements for downloading the data from the server.

GeoMobile

Mobile Connectivity

Testing the mobile internet connection for
the mobile platform

GeoMobile

Mobile Internet Connections

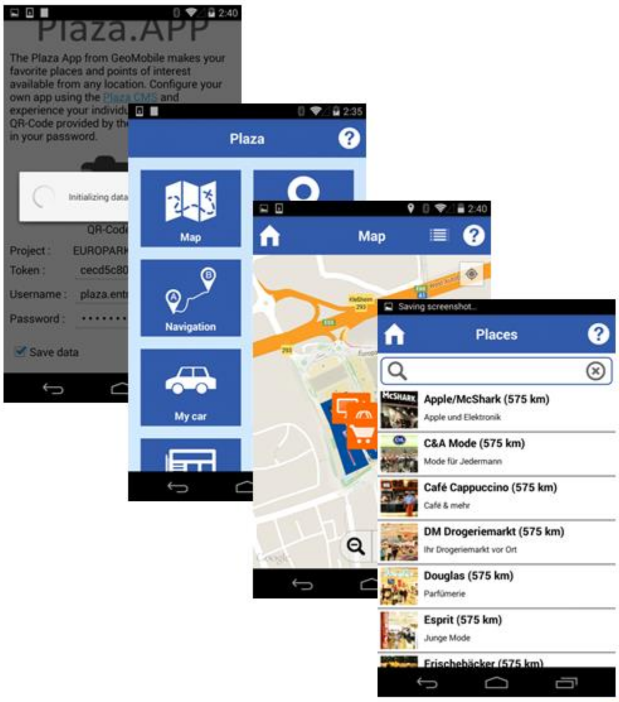
- Mobile internet connection
  - WiFi
  - 2G, 3G, 4G
- Influencing factors
  - Indoor vs. Outdoor
  - Distance to cell tower
  - Cellar vs. Roof
  - Count of walls
  - Building construction
  - Simultaneous user
  - ...

Speed	Down	Up
GSM GPRS	56 to 115 Kbit/s	56 to 115 Kbit/s
GSM EDGE	Up to 237 Kbit/s	Up to 237 Kbit/s
UMTS HSPA	14,4 Mbit/s	5,8 Mbit/s
HSPA+	21-672 Mbit/s	5,8 to 168 Mbit/s
LTE	100 to 300 Mbit/s	50-75 Mbit/s

GeoMobile

Selection of activities

- Initializing / Reopen the app
  While initializing the app, the textual descriptions of places, tours, news, information, etc. are downloaded.
- Map view
  The tiles for the map are downloaded as needed (zoom factor, bounding box, etc.)
- Places list view
  The names of the places are already available (see initializing), but the pictures are loaded as needed.



GeoMobile

First load of activity

Connection type*	Initializing	Map view	Placeslist	Average
WiFi in the office	7,2	1,5	<1	3,23
HSPA	13,4	4,2	1,5	6,37
EDGE	23,2	8,7	3,2	11,7
GPRS	78,5	34,3	15,3	42,7

*Average in seconds of 20 tests.

GeoMobile

Review of activity (Cached)

Connection type*	Reopen	Map view	Placeslist	Average
WiFi in the office	<1	<1	<1	<1
HSPA	<1	1,1	<1	1,03
EDGE	<1	2,8	<1	1,6
GPRS	<1	5,2	<1	2,4

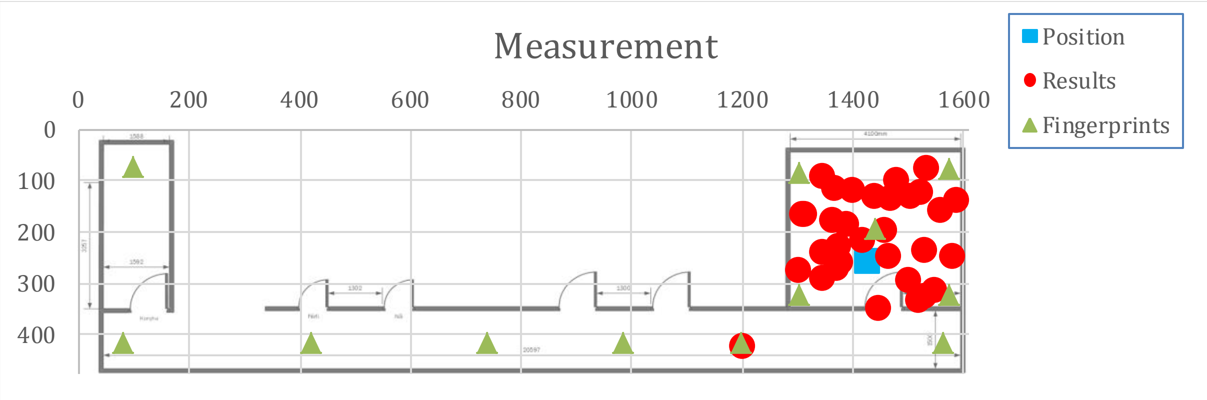
*Average in seconds of 20 tests.

ANNEX D

GFTH Inc. Entrance test results:

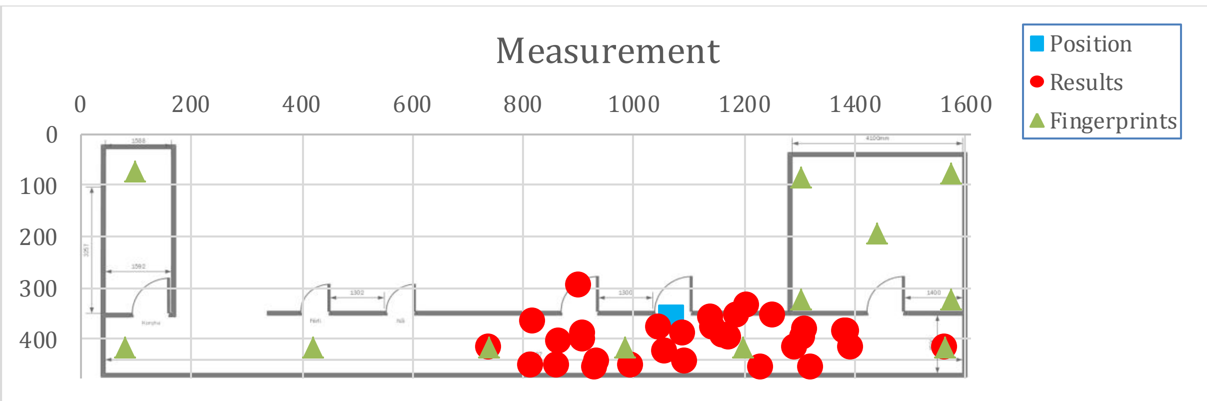
1. First test, Dolmány str.:

		X (pixel)	Y (pixel)			X (pixel)	Y (pixel)
Position:		1430	258				
Result:	0	1526	125	**Fingerprint:**	0	1576	81
	1	1467	249		1	1576	326
	2	1404	120		2	1305	326
	3	1592	143		3	1307	85
	4	1371	118		4	1443	196
	5	1484	104		5	1568	420
	6	1382	264		6	988	418
	7	1317	167		7	1200	418
	8	1523	338		8	743	420
	9	1442	135		9	424	418
	10	1538	80		10	82	420
	11	1534	240		11	103	75
	12	1460	201				
	13	1534	328				
	14	1391	189				
	15	1420	221				
	16	1505	296				
	17	1348	94				
	18	1204	425				
	19	1351	244				
	20	1373	275				
	21	1551	317				
	22	1585	250				
	23	1472	138				
	24	1562	160				
	25	1509	135				
	26	1380	231				
	27	1450	350				
	28	1366	181				
	29	1349	293				
	30	1313	170				
	31	1307	278				



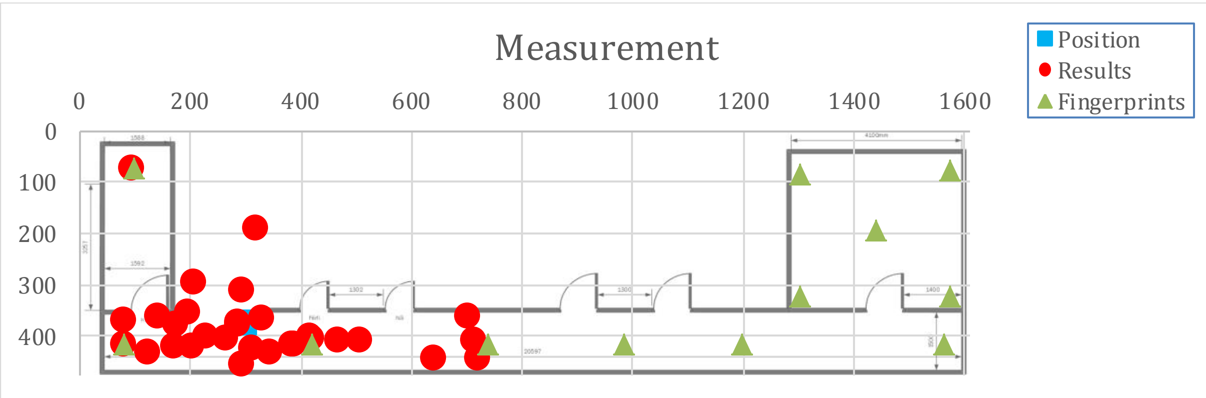
2. Second test. Dolmány Str.

		X (pixel)	Y (pixel)			X (pixel)	Y (pixel)
Position:		1071	360				
Result:	0	1142	360	**Fingerprint:**	0	1576	81
	1	1059	427		1	1576	326
	2	1384	388		2	1305	326
	3	1389	387		3	1307	85
	4	1164	396		4	1443	196
	5	999	453		5	1568	420
	6	1397	418		6	988	418
	7	743	420		7	1200	418
	8	821	367		8	743	420
	9	1325	457		9	424	418
	10	1177	398		10	82	420
	11	1233	457		11	103	75
	12	1189	354				
	13	1566	418				
	14	936	446				
	15	1050	381				
	16	905	296				
	17	913	402				
	18	1096	447				
	19	863	453				
	20	1207	338				
	21	817	453				
	22	1308	397				
	23	1295	417				
	24	1312	384				
	25	1092	390				
	26	1148	378				
	27	870	408				
	28	932	458				
	29	1255	356				
	30	912	390				



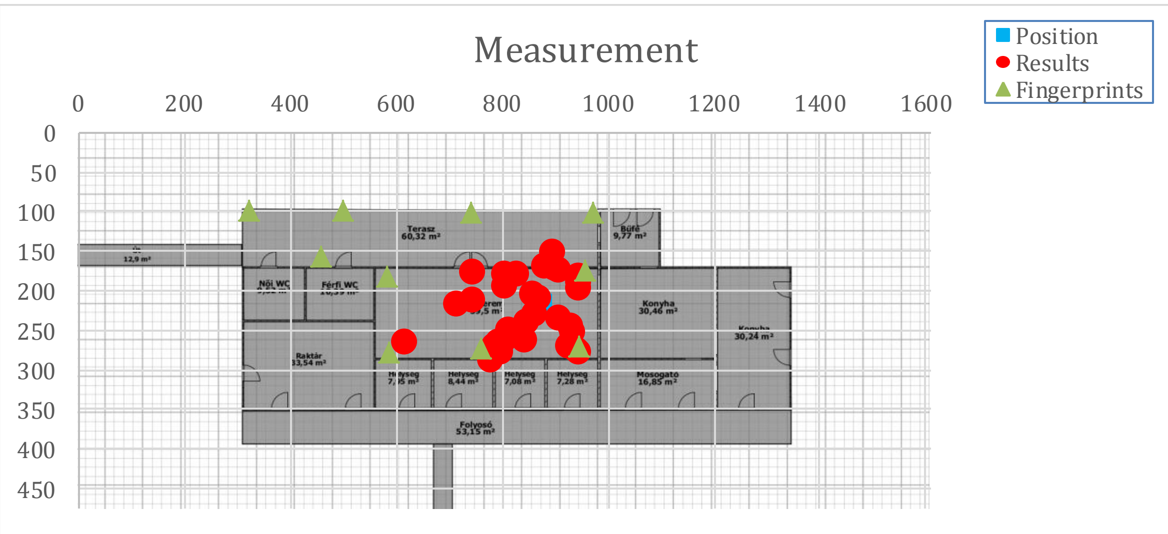
3. Third test Dolmány Str.

		X (pixel)	Y (pixel)			X (pixel)	Y (pixel)
Position:		302	376				
Result:	0	512	412	**Fingerprint:**	0	1576	81
	1	472	409		1	1576	326
	2	718	412		2	1305	326
	3	297	457		3	1307	85
	4	267	407		4	1443	196
	5	333	367		5	1568	420
	6	230	403		6	988	418
	7	144	363		7	1200	418
	8	127	433		8	743	420
	9	644	444		9	424	418
	10	85	370		10	82	420
	11	295	314		11	103	75
	12	424	406				
	13	177	378				
	14	723	445				
	15	391	417				
	16	347	433				
	17	211	296				
	18	207	423				
	19	99	74				
	20	198	354				
	21	420	404				
	22	386	420				
	23	175	423				
	24	321	193				
	25	290	378				
	26	82	420				
	27	314	425				
	28	704	362				
	29	290	374				



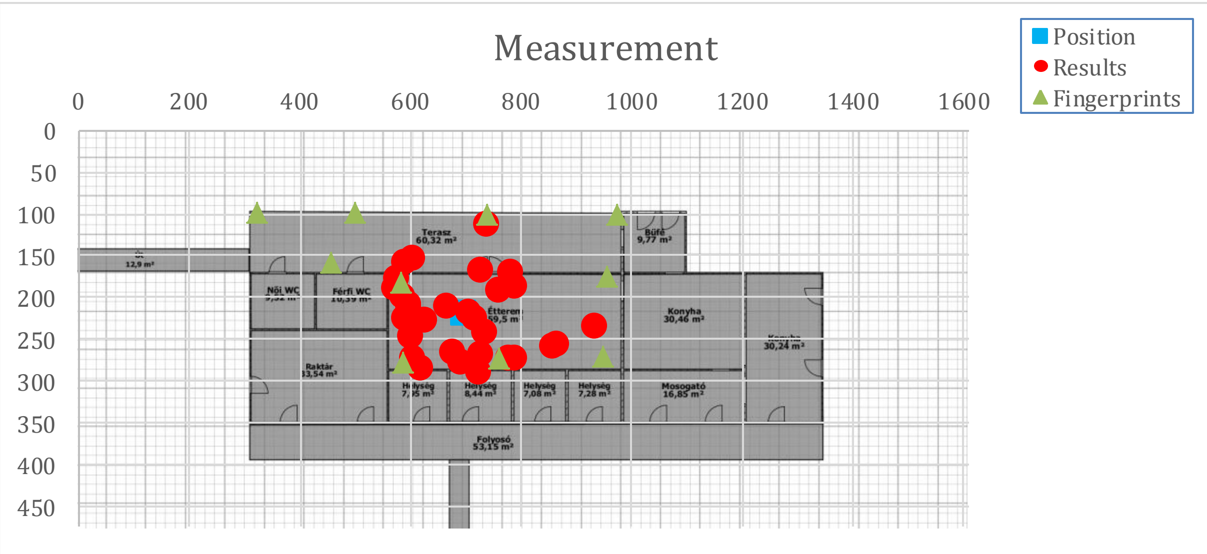
4. Fourth test Jávorkút.

		X (pixel)	Y (pixel)			X (pixel)	Y (pixel)
Position:		873	220				
Result:	0	796	265	**Fingerprint:**	0	586	183
	1	901	153		1	591	279
	2	933	245		2	960	176
	3	817	250		3	950	271
	4	830	180		4	762	274
	5	860	206		5	975	101
	6	864	231		6	460	158
	7	845	264		7	324	99
	8	809	263		8	743	102
	9	750	212		9	503	99
	10	948	278				
	11	749	177				
	12	937	252				
	13	781	288				
	14	939	271				
	15	873	210				
	16	791	270				
	17	910	175				
	18	948	197				
	19	720	217				
	20	801	278				
	21	930	271				
	22	886	171				
	23	944	275				
	24	910	235				
	25	810	181				
	26	618	265				
	27	947	182				
	28	948	190				
	29	903	173				
	30	808	196				
	31	852	241				



5. Fifth test, Jávorkút

		X (pixel)	Y (pixel)			X (pixel)	Y (pixel)
Position:		700	218				
Result:	0	580	178	**Fingerprint:**	0	586	183
	1	867	256		1	591	279
	2	621	284		2	960	176
	3	794	274		3	950	271
	4	599	212		4	762	274
	5	860	258		5	975	101
	6	631	227		6	460	158
	7	574	190		7	324	99
	8	785	171		8	743	102
	9	670	210		9	503	99
	10	730	168				
	11	592	158				
	12	937	236				
	13	781	272				
	14	606	248				
	15	728	289				
	16	600	208				
	17	592	226				
	18	763	193				
	19	693	277				
	20	731	269				
	21	791	188				
	22	741	114				
	23	681	267				
	24	607	274				
	25	601	218				
	26	603	221				
	27	608	153				
	28	720	225				
	29	591	198				
	30	710	218				
	31	738	241				



6. Sixth test, Jávorkút

		X (pixel)	Y (pixel)			X (pixel)	Y (pixel)
Position:		408	127				
Result:	0	422	130	**Fingerprint:**	0	586	183
	1	443	109		1	591	279
	2	387	123		2	960	176
	3	441	153		3	950	271
	4	550	175		4	762	274
	5	394	102		5	975	101
	6	486	131		6	460	158
	7	416	108		7	324	99
	8	371	134		8	743	102
	9	399	122		9	503	99
	10	439	134				
	11	561	181				
	12	455	123				
	13	471	103				
	14	379	149				
	15	475	128				
	16	597	104				
	17	445	150				
	18	381	142				
	19	549	140				
	20	366	102				
	21	395	123				
	22	462	150				
	23	414	147				
	24	384	135				
	25	477	131				
	26	408	113				
	27	501	106				
	28	421	116				
	29	512	107				
	30	425	146				
	31	467	132