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Blind People's Navigation Improvements Using Crowdsourcing

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Content

1. Abstract

- ✓The literature review and survey of the blind and severely visually impaired (BSVI) people showed that BSVI (blind and severely visually impaired) are using the same general-purpose or specialized social networking means for communication, learning, remote working, leisure, navigation as other people.
- ✓BSVI oriented text (and image) to voice, tactile feedback, and other specialized mobile apps or software and hardware solutions help in this matter.
- ✓This paper studies how crowdsourcing (participatory social networking) can improve navigation and orientation capabilities outdoors and indoors, using the computer vision-based ETA (electronic traveling aid) approach.
- ✓This study gives insights into the high potential of crowdsourcing usage to improve BSVI people’s ETA performance.
- ✓In this regard, this paper delivers a short overview, BSVI survey results, and a description of the prototype, which we are developing to meet BSVI expectations.
- ✓Provided insights can help researchers and developers to exploit social Web and crowdsourcing opportunities for BSVI computer vision-based ETA navigation improvements.

2. **Introduction**

- ✓ **A wide range of general-purpose social networks, web 2.0 media apps, and other smart ICT (information and communication technology) tools are not destined to meet specialized requirements of BSVI people, but some adds make them useful...**
- ✓ **Only a few social networking platforms are specifically oriented for BSVI users...**
- ✓ **According to Raufi et al. [1], the volumes of information together with data from social networks confuse BSVI users. In this way, web 2.0 social networks do not guarantee specialized digital content accessibility for BSVI users [2]. Some more focused approaches are in demand...**
- ✓ **BSVI surveys reveal that social networking apps are among five most popular mobile apps [11]. The majority of BSVI people - who use social media - choose Facebook social networks [4], [9], [10].**
- ✓ **Next to the general-purpose social networks, BSVI people frequently use apps specifically designed for them to accomplish daily activities like Walky Talkie, The vOICe for Android, Ariadne GPS, BlindSquare** ...
- ✓ **The above mentioned cases and some other navigation apps are mostly based on the pre-developed navigational information, but do not provide a real-life support, user experience-centric approaches, and participatory Web 2.0 social networking.**

3. BSVI People's Survey (1/3)

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- ✓To define more precisely BSVI persons' social networking needs and expectations concerning navigation help, we conducted a semi-structured interview.
- ✓In total, 78 EU located BSVI persons' responses were analyzed (see Fig. 1), of which 25 were identified as blind experts (10+ years of experience or active interest in using ETAs for the blind).
- ✓In the survey, some questions (out of 40 questions in total) concerned ETA navigation functionalities, and others dealt with social networking approaches.
- ✓25 BSVI experts also provided their answers, see Fig. 2. They were interviewed concerning the usage of smartphone apps and Web portals.
- ✓Based on the entire survey analysis, we find out some perspective niche of research and development in the field of navigational ETA solutions. Based on these insights, we made some inferences regarding a combination of modern enabling technologies, which can be successfully employed.

3. **BSVI People's Survey (2/3)**

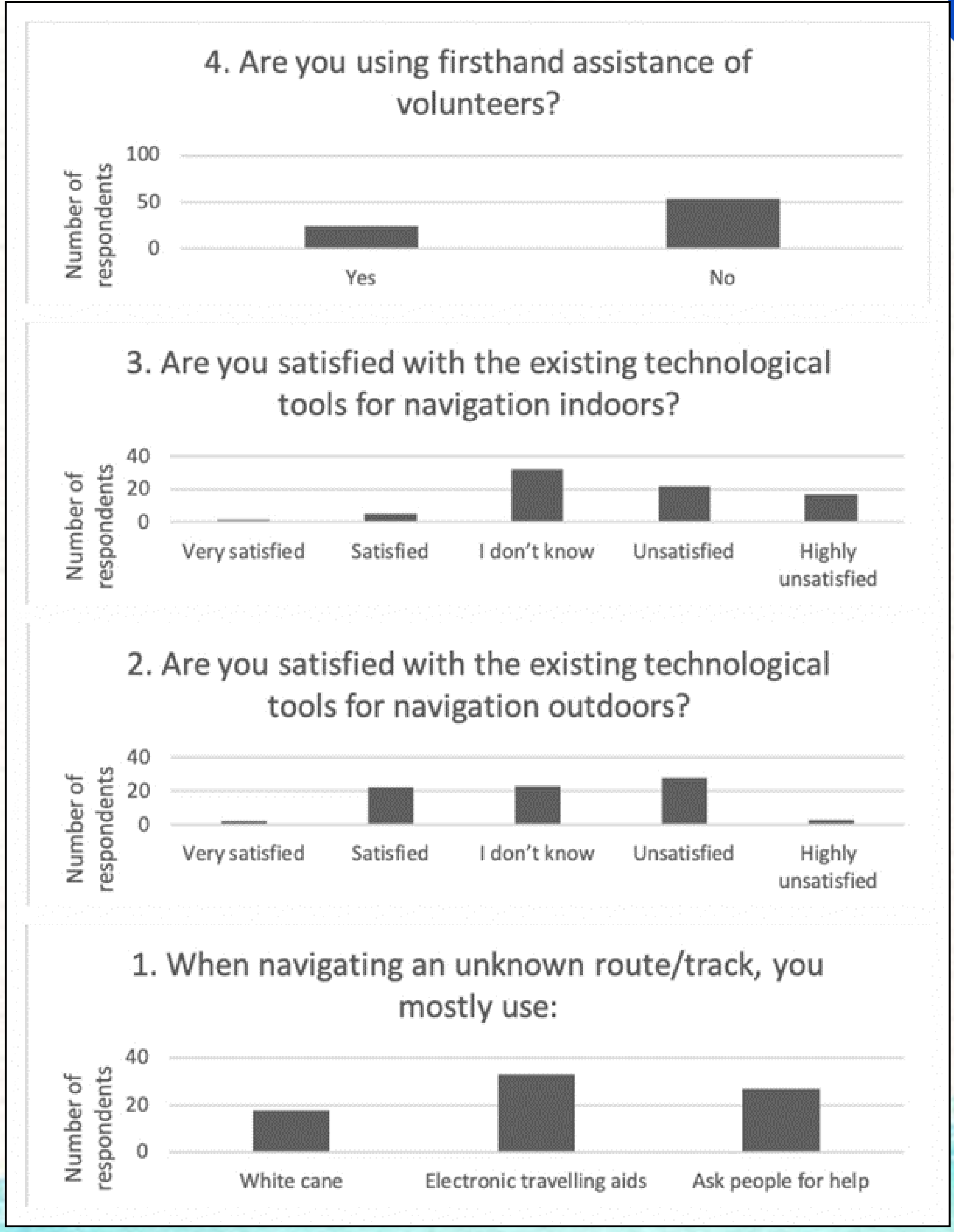

Figure 1. Survey responses from 78 BSVI persons.

3. **BSVI People's Survey (2/3)**

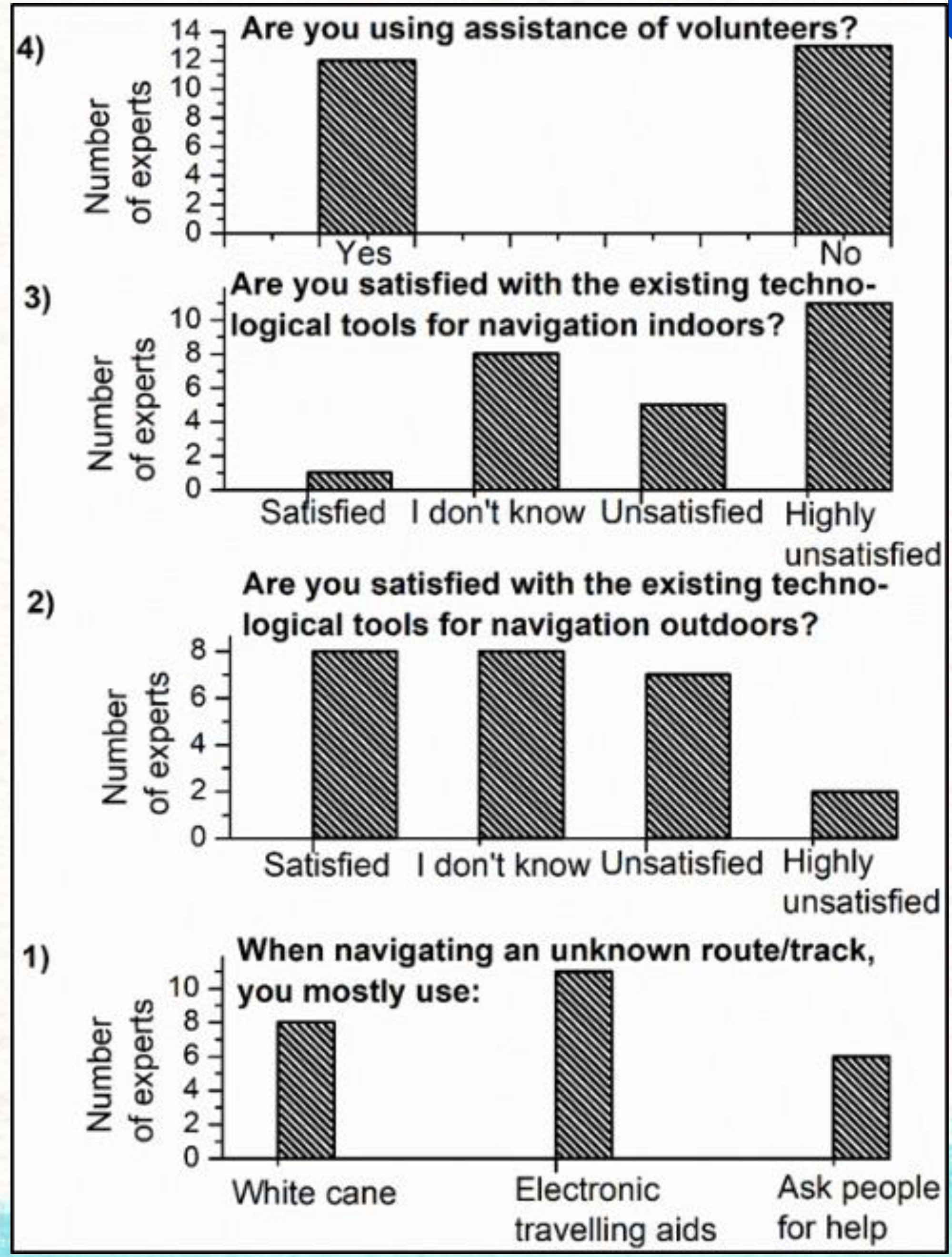

Figure 2. Survey responses from 25 BSVI experts.

4. MACHINE VISION-BASED NAVIGATION ENHANCEMENTS USING PARTICIPATORY SOCIAL NETWORKING (1/7)

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✓ **In the case of real-time assistance and guidance' for traveling routes, the primary objective of the specialized mobile app's with wearable services is to assist a visually impaired or blind user in navigating from the chosen point A to point B using reliable directions given from an online community. For instance,**

- SoNavNet is designed for connected users of the social network to share navigation information with the intent of providing more personalized navigation methods, routes based on member experience rather than the shortest distance [16].

- Tales4Us platform to promote creativity, collaboration, and learning process, for a BVSI and other communities to share their shopping stories through a specialized social network. The application has such major functionalities: (i) the user can play other users' shopping stories, (ii) users can record new stories and share it with the community.

- In the case of "Seeing-eye person" proposed in [18], a crowdsourcing approach enables multimedia data sharing and services for the BSVI navigation. The goal of this work is to provide user-accessible crowd services.

4. MACHINE VISION-BASED NAVIGATION ENHANCEMENTS USING PARTICIPATORY SOCIAL NETWORKING (2/7)

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In our ETA R&D project, we also use the onboard sensors of a smartphone (iPhone or Android Phone), such as a camera, compass, GPS, and accelerometer, to assist the navigation of a blind user, see Fig. 3.

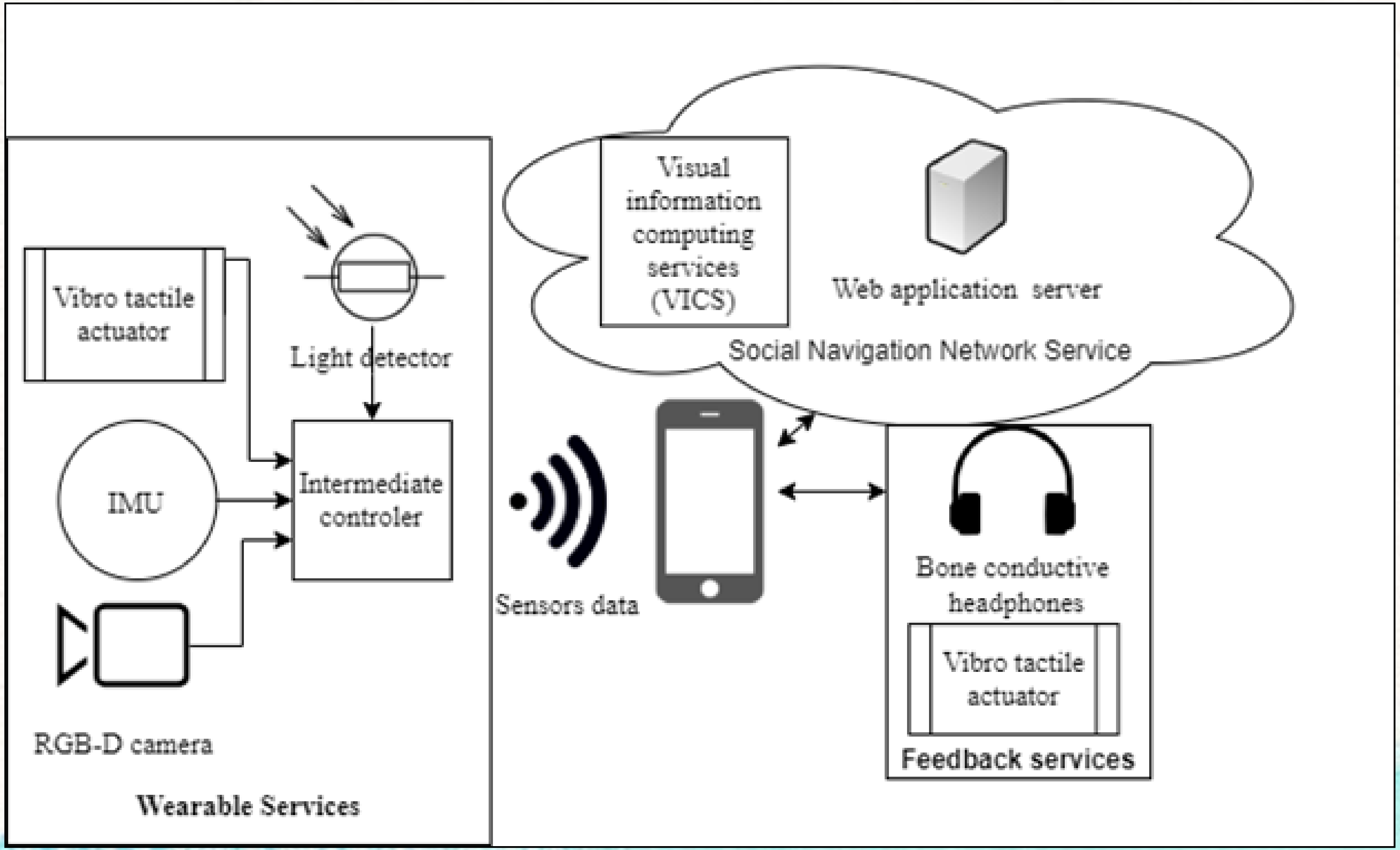

Figure 3. Social navigation network services enabled by mobile device for BSVI

4. MACHINE VISION-BASED NAVIGATION ENHANCEMENTS USING PARTICIPATORY SOCIAL NETWORKING (3/7)

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The primary function of mobile computing is to stream the video and other sensory information to the crowd server so that volunteers can use the information to provide service.

The challenge: to tailor these techniques in order to address the unique challenges in crowd-assisted navigation, such as the smoothness and reliability of visual labeling of routes recorded by volunteers, and the contextual information of video frames.

Besides, we also need to consider the synchronicity of data coming from different volunteers and the frequency of instructional updates.

The seamless integration of AI-based vision algorithms in the crowdsourced social networking solutions can provide additional feedback. Vision-based algorithms can be tested for accuracy against live information from human volunteers. Along with the on-line process and data aggregation, an offline analysis will in turn help better tailor context-aware human-computer interfaces and further improve the online analysis tasks.

4. NAVIGATION ENHANCEMENTS USING PARTICIPATORY SOCIAL NETWORKING (4/7)

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Based on the survey results and above mentioned considerations, we are reporting an interim result - a prototype of a wearable system configured to help as an offline and online web-crowd assisted decision support system for blind and visually impaired (BVI) people when orientating and navigating in indoor environments (for instance, public institutions, schools, hospitals, airports, stores, and other buildings).

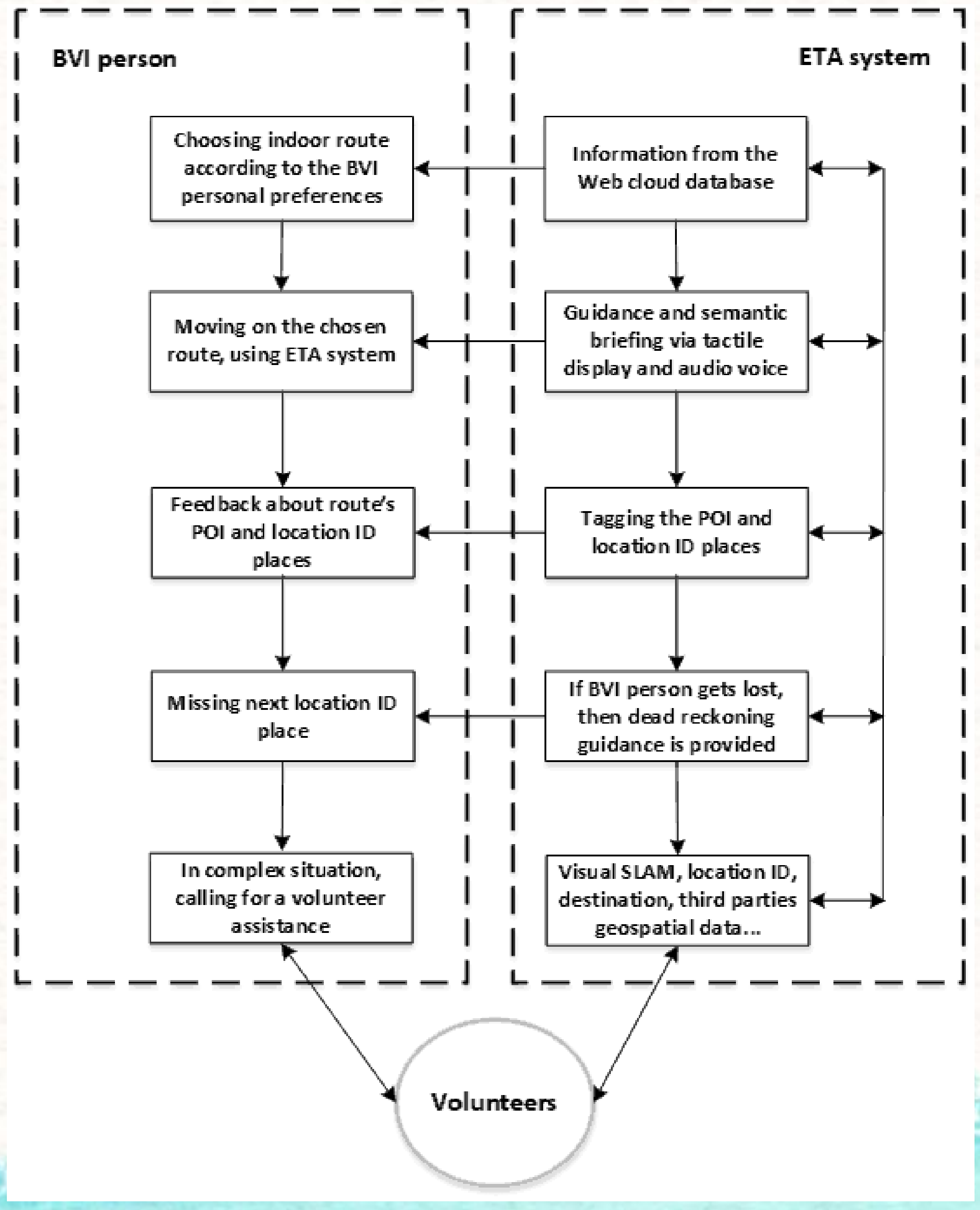
Admittedly, there is a lack of feasible indoor navigational solutions that would work well without GPS signal and prearranged infrastructural indoor installations (such as WI-FI routers, beamers, RFID tags).

Our survey of blind experts has shown that after outdoor navigation, the second most demanded and not satisfied need concerns electronic traveling aid (ETA) solutions for indoor navigation and orientation [12, 13], see Fig. 4.

The presented system is a compound technology of innovatively adapted hardware devices like the 3D ToF IR camera, RGB camera, specially designed tactile display with EMG sensors, bone-conducting earphones, controller, and IMU, GPS, light detector, compass sensors. GSM communication can be implemented as a stand-alone device or smartphone that can work as an intermediate processing device.

4. NAVIGATION ENHANCEMENTS USING PARTICIPATORY SOCIAL NETWORKING (5/7)

Figure 4. Web crowd (volunteers) assisted method for indoor routing enhancement and optimization, using ETA system functionality



4. NAVIGATION ENHANCEMENTS USING PARTICIPATORY SOCIAL NETWORKING (6/7)

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The devices and sensors observe the environment in real-time and send data via the controller to the machine learning processing, where features' extraction, object recognition, and data storage occur in the web cloud database server, see Fig. 4. The prototype integrates devices and interfaces using modern technologies and methods from machine learning and computational vision domain.

From the point of view of the end-user, this prototype distinguishes among other related wearable indoor navigational ETA novelties in the sense of

a) intelligent user interface integrity based on unique tactile display and audio instructions,

b) hands-free intuitive control interface using EMG (electromyography),

c) comfortable user-orientated headband design,

d) machine learning-based real-time guidance,

e) web-crowd assistance while mapping indoor navigational routes and solving problematic situations on the way.

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4. NAVIGATION ENHANCEMENTS USING PARTICIPATORY SOCIAL NETWORKING (6/7)

For efficient indoor navigational performance, the presented ETA system is used in three consequently interconnected modalities:

(i) Web crowd assistance when volunteers go through buildings and gather step-by-step indoor routes' information that is processed in the web cloud server and stored in the online DB;

(ii) BVI usage of web cloud DB indoor routes when they need guided navigational assistance;

(iii) in complex indoor situations (such as getting lost, encountering unexpected obstacles and situations), the BVI ETA system's multisensory data stream can be used in real-time to get voice-guided help from volunteers familiar with the particular route or building.

More prototype R&D details are available in the short video presentation (look for the Indoor NavGuide video link at our project web page):

SightCity Frankfurt 2021 - FTS-Project (vgtu.lt)

5. Conclusions

We presented how crowdsourcing (participatory social networking) can improve navigation and orientation capabilities outdoors and indoors, using the computer vision-based ETA (electronic traveling aid) approach.

This presentation delivers a short overview of related research, BSVI survey and blind experts interview results, wherein semi-structured survey revealed a clear lack of participatory Web 2.0 social networking usage for the navigation and orientation outdoors and indoors.

We also provide a short description of the guided navigation prototype, which we are developing to meet BSVI expectations for orientation indoors.

We adapted machine vision algorithms that provide directional information while navigating indoors.

The presented ETA system uses crowdsourcing when volunteers go through buildings and gather step-by-step indoor routes' visual and other sensory information that is processed, using machine learning algorithms, in the web cloud server and stored for the BSVI usage in the web cloud DB. BSVI can use the routes' DB for navigation indoors.

In time, a participatory web 2.0 social networking platform – something like a worldwide “Visiopedia - with big, labeled, crowdsourced, almost real-time updated, and publicly available outdoor and indoor navigational database for BSVI could emerge.

Provided insights can help researchers and developers to exploit social Web and crowdsourcing opportunities for BSVI computer vision-based ETA navigation improvements.

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