Embedded System Concept Supporting Spatial Orientation Using ToF Distance Sensors

Marta Szymczyk
AGH University of Krakow, Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering,
Al. Mickiewicza 30, 30-059 Krakow, Poland

Abstract: The author propose an outline of concept of embedded system designed to support spatial orientation for both visually impaired individuals and emergency personnel (e.g., firefighters) operating in low-visibility environments such as smoke-filled or dark areas. Personal Spatial Orientation Support System uses sixteen Time-of-Flight distance sensors arranged around the user, enabling distance measurements in all directions. Sensor data will be processed by artificial neural networks that classify obstacles and estimate their relative positions. The system will provide real-time information on object distances and movements. The proposed system can significantly enhance safety and independence for users in diverse environments, representing an innovative step toward intelligent navigational aids for people with visual impairments.

Keywords: intelligent navigational aids, spatial orientation, embedded system, Time-of-Flight distance sensors, artificial neural networks, wearable body system

1. Introduction

Orientation in space is a crucial part of our daily life. A person, thanks to his senses and the brain's ability to interpret information from them, is able to determine the location of surrounding objects can operate safety and efficiently in the surrounding environment. The sense of sight plays a key role here but in situations where a person has a visual impairment or inconvenient environmental conditions (smoke, fog, darkness, etc.) prevent the use of this sense. The need to replace this sense with a technical solution becomes an important issue [8–12]. The paper proposes an outline of concept of technical solution based on a set of Time-of-Flight (ToF) sensors and software in the form of deterministic algorithms and as well as an artificial neural network, which can provide a solution to the described problem. Orientation in space can be based on different types of sensors such as:

- Vision Cameras (RGB) [1],
- Depth Cameras (RGB-D) [2],
- Lidars (Light Detection and Ranging) [3],
- Radars [4],
- Sonars – ultrasonic sensors [5],
- Acceleration Sensors (ACC) and gyroscopes (GYRO) [A1],
- Global positioning (GPS/GNSS) [6],
- Local positioning (LPS) [7].

The solutions listed above have disadvantages or features that prevent them from being used for a Wearable Body Sensor system (WBS) inside a building in conditions of low visibility or visual impairment. Therefore, the following general features have been defined for the designed Personal System to Support Spatial Orientation (PSOSS):

- Works in low visibility conditions,
- Convenient – lightweight, comfortable to use,
- Cheap,
- Autonomous,
- Precise,
- Energy-efficient.

Table 1 shows a comparison of the general features of various solutions, which shows that the proposed ToF-based PSOSS system is the most promising.

The proposed solution can also be used in other cases, such as autonomous robots, drones, autonomous vehicles, etc.

In conclusion, the main research problem is to replace sight by relatively cheap and simple device which would enable spatial orientation and threat detection, for example approaching object.

Autor korespondujący:
Marta Szymczyk, mszymczyk@agh.edu.pl

Artykuł recenzowany
nadesłany 13.01.2026 r., przyjęty do druku 22.06.2026 r.

2. Description of the proposed solution

2.1. System architecture

The main component of the proposed PSOSS system is a set of 16 sensors arranged on a headband or helmet around and at the height of the wearer's head, as shown in Fig. 1. This

Table 1. Comparison of sensor characteristics
Tabela 1. Porównanie charakterystyk czujników

Sensor	Works in the low visibility conditions	Convenient	Cheap	Autonomous	Precise	Energy-efficient
Vision Camera	NO	Average	NO	YES	Average	NO
Depth Cameras	NO	Average	NO	YES	Average	NO
Lidar	YES	NO	NO	YES	YES	NO
Radar	YES	NO	NO	YES	YES	NO
Sonar	YES	YES	YES	YES	NO	YES
GPS/GNSS	YES	YES	YES	NO	NO[1]	YES
LPS	YES	NO[2]	YES	NO	Average	NO[2]
ToF	YES	YES	YES	YES	YES	YES

[1] Limited functionality in the internal environment
[2] Special infrastructure is needed

sensor placement allows the user to monitor their surroundings based on their head movement, which reflects their primary area of interest.

The placement of sensors on the user's head was inspired by the positioning of analogous devices on robots, where sensors are typically mounted as high as possible for example on the upper part of a robot's enclosure.

Alternative sensor placements were also considered; however, positioning distance sensors on the user's head in the form of a headband appears promising and advantageous. This is due to the natural tendency of humans to orient their head toward the direction of interest. In such a case, the data from the distance sensors are inherently coupled with the current head orientation. When the user's area of interest changes, the head position and consequently the sensor orientation changes as well. As a result, data from certain sensors (e.g., those facing forward) can be treated as higher priority and subjected to more detailed analysis, for example in the context of detecting approaching objects during motion.

Additionally, the integration of inertial sensors such as linear and angular acceleration sensors, as well as a magnetometer may provide further information about head movement and orientation, and consequently about the positioning of the distance sensors. Such information could further support data processing and situational awareness in the surrounding environment.

The proposed placement of sensors on the head constitutes a research hypothesis that will be experimentally verified. If this solution proves problematic, alternative configurations will be considered, such as placing the sensors at the level of the user's chest or around the waist.

Data will be calculated and interpreted accordingly based on head movement. Should this placement pose a problem, the sensors can be placed at chest level. The sensors are arranged in two rows and at an angle. The bottom sensor is oriented so that it "observes" the area from vertically down to 45°, while the second sensor is oriented from 45° to horizontal. Such placement of sensors allows to obtain an image of the environment in a resolution of 126 by 512 points of distance measurement with an angle of observation from 0 to 90 degrees, as shown in Fig. 2. The vertical solution is 126 points as two sensors were used. They are placed on top of each other, as shown in Fig. 1 (a). The horizontal resolution is 512 points, because eight sensors were used around the head, as shown in Fig. 1 (b).

The data obtained in this way will be collected by the microcontroller and after preprocessing, sent via Bluetooth Low Energy (BLE) wireless link to the smartphone, where in the implemented application data processing takes place. The architecture of the proposed solution is shown in Fig. 3. Such a solution ensures optimal use of resources and the ability to save energy what has a direct impact into the lifetime of the system without the need to replace batteries or recharge batteries.

Figure 2 shows the range of the sensors (in red). The area highlighted in yellow is the observation area of the bottom sensor. It is limited by the 45° angle and the floor from below. The green area, on the other hand, is for the upper sensor, bounded by the 45° angle, the floor from below and the range of operation as an arc.

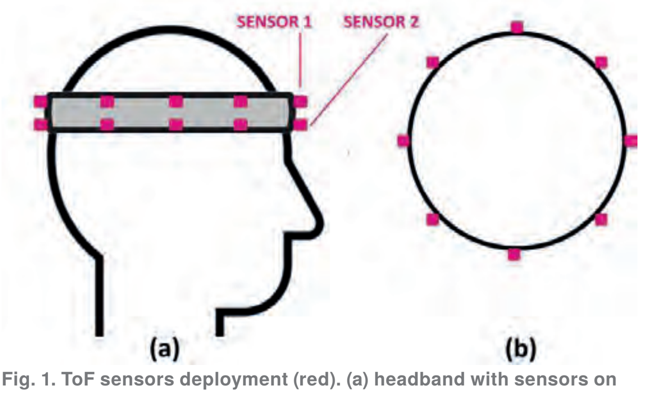

Fig. 1. ToF sensors deployment (red). (a) headband with sensors on head side view, (b) headband with sensors top view
Rys. 1. Rozmieszczenie czujników ToF (czerwony). (a) opaska z czujnikami na głowie, widok z boku, (b) opaska z czujnikami, widok z góry

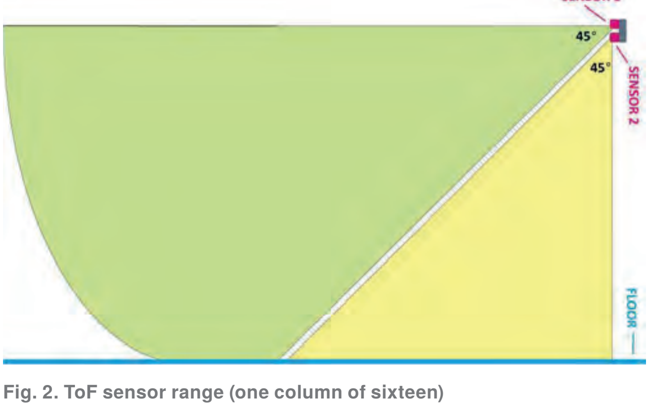

Fig. 2. ToF sensor range (one column of sixteen)
Rys. 2. Zakres czujnika ToF (jedna kolumna z szesnastu)

The system shown in Fig. 3 consists of sixteen ToF sensors connected to the I2C bus. The microcontroller receives data from the I2C bus and sends it via BLE to a smartphone application. It is also possible to use an autonomous system instead of a smartphone.

It is also possible to use an autonomous system instead of a smartphone, or to employ a smartphone for further data transmission via BLE, Wi-Fi, or cellular networks such as GSM, LTE, or 5G. This transmission may be directed either to a local or remote PC, as well as to cloud infrastructure. Further data processing and analysis based on sensor inputs could also be performed there. Additionally, feedback commands could be sent back to the smartphone for example, providing voice or visual notifications about the surrounding environment, recognized objects, or alerts regarding detected threats (e.g., a rapidly approaching object). The final optimal solution will be determined based on tests and experimental validation of the proposed concept.

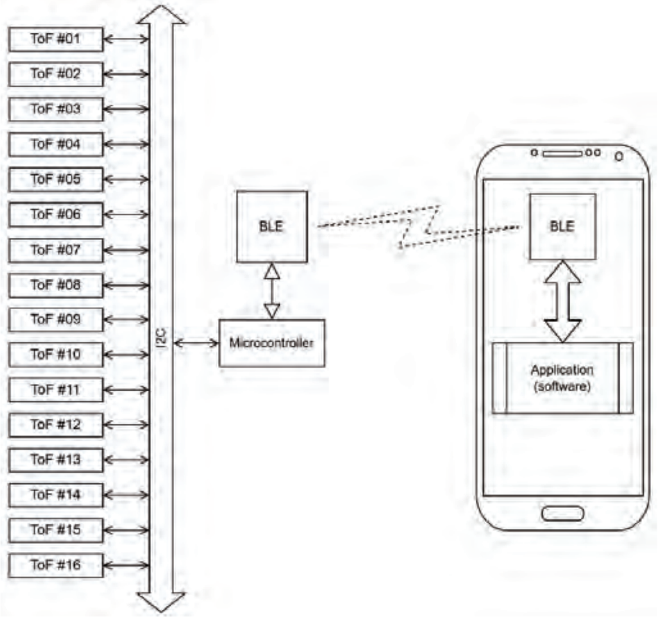

Fig. 3. PSOSS system architecture
Rys. 3. Architektura systemu PSOSS

2.2. ToF Sensor

The VL53L5CX [A2] sensor from STMicroelectronics was used in the project. This sensor is currently one of the most modern distance sensors. It is based on Time-of-Flight technology and importantly, is a multi-zone solution (allows simultaneous distance measurement in multiple areas). It has high performance parameters (Table 2) and it is preferred in demanding applications.

2.2.1. Principle of operation

Figure 4 shows the principle of operation of the ToF detector. A short pulse of light is sent out from the laser, bounces off the obstacle encountered and returns to the detector. The pulse return time is measured and the distance d to the obstacle is calculated on this basis.

2.2.2. Architecture of the VL53L5CX sensor

The VL53L5CX sensor consists of the following modules integrated in-side a single integrated circuit:

- Vertical Cavity Surface Emitting Laser (VCSEL) (IR+,IR-) – light source in the 940 nm range (invisible infrared), emits short pulses of infrared light;
- Single Photon Avalanche Diode (SPAD) detection array – array of photodetectors recording single photons, allows precise determination of light transit time, works for each of the 8 × 8 zones separately;

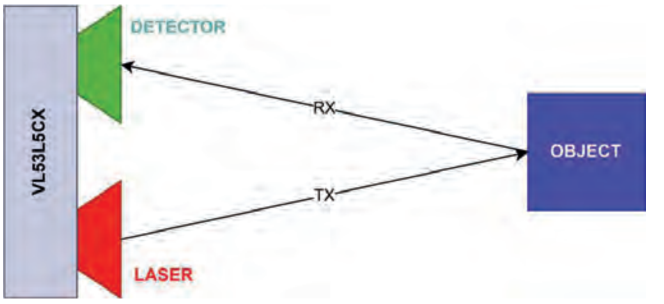

Fig. 4. The working principle of operation of sensor
Rys. 4. Zasada działania czujnika

- Non Volatile Memory – non-volatile memory (retains data when power is removed), stores calibration and configuration and identification data;
- ROM – contains firmware type software;
- RAM – contains RAM for microcontroller, measurement data buffer, temporary program data, communication buffer;
- Microcontroller – built-in microcontroller that processes data locally, handles calibration and temperature compensation algorithm, manages I2C communication;
- Advanced Ranging Core – this module processes the data received from the SPAD array, creates depth maps in real time, compensates for noise and post-improves accuracy;
- VCSEL Driver – a control chip that manages the operation of the VCSEL laser.

2.2.3. MiniPCB Module

STMicroelectronics has created miniPCBs [A5, A6] to make prototyping easier with VL53L5CX sensors. This gives you the opportunity to use the modules quickly without having to design and make your own PCB. Such a board contains, in addition to the sensor itself, an XC6222D331MR-G voltage regulator from Torex Semiconductor. This module has very small dimensions (12 mm × 14 mm) which facilitates its practical use in the described project.

2.2.4. Key applications

This sensor is very popular and is eagerly used in the following applications [A4]:

- Scene understanding,
- 3D room mapping,
- Obstacle detection for robotics applications,
- Content management (load in trucks, tanks, waste bins),
- Gesture recognition,
- Liquid level control,
- Smart buildings and smart lighting (user detection to wake up devices),
- Keystone correction for video projectors,
- Laser-assisted autofocus (LAF),
- Augmented reality/Virtual reality,
- IoT (user and object detection).

2.3. Microcontroller

The project will use the STM32F401RET6 microcontroller [A7] from STMicroelectronics.

The microcontroller has appropriate parameters for this application. In addition, STMicroelectronics has prepared a rich set of library software to support VL53L5CX sensors for this microcontroller [A8] which makes software development much faster and easier than if another had been chosen. It communicates via I2C with the 16 VL53L5CX sensors and with the BLE module via SPI. It receives data from the sensors, processes it and sends it to an application on a smartphone.

Table 2. VL53L5CX sensor parameters based on datasheet
Tabela 2. Parametry czujnika VL53L5CX na podstawie karty katalogowej [A3]

Parameter	Value	Remarks
Range	0.1 cm to 400 cm	up to 350 cm for 64 zones
Laser wavelength	940 nm	
Number of zones	64	8 × 8
Frame rate capability	60 Hz	15 Hz for 64 zones
Field of view (FoV) (vertical/horizontal)[1]	45°/45°	
Field of view (FoV) (diagonal)[1]	63°	
Accuracy for distance 2–20 cm	±15 mm/15 mm	0 klux/5 klux [2]
Accuracy for distance above 20 cm	±5 %/8–11 %	0 klux/5 klux [2]
Standard I2C address	0x52	Can be changed
Communication bus	I2C	Pull-ups SCL and SDA
I2C Bus frequency	400 kHz to 1 MHz	
Supply voltage	3.3 V or 2.8 V	
Optimal operating temperature	–30 °C to 85 °C	
Measurements	6.4 mm × 3.0 mm × 1.5 mm	
Weight	0.5 g	

[1] Figure 5 shows the FoV
[2] for 8 × 8, 15 Hz

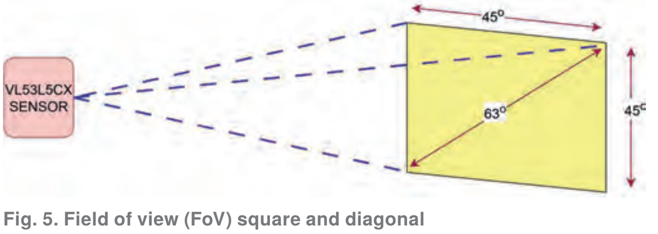

Fig. 5. Field of view (FoV) square and diagonal
Rys. 5. Pole widzenia (FoV) kwadratowe i przekątne

2.4. BLE Module

ST67W611M1 module from STMicroelectronics [A9] (Fig. 6) enables communication in several standards. The project utilizes BLE for communication. The operating principle is explained in chapter 2.5.2.

An additional advantage of this solution is the availability of ready-made printed circuit board (PCB), which significantly speeds up the launch of equipment.

2.5. Data transmission

2.5.1. Standard I2C

The I2C transmission standard [A3] will be used in the project to connect the sensors to the microcontroller.

Using commands sent by the microcontroller (master) to this bus, the following operations on VL53L5CX sensors are possible [A10]:
- Sensor initialization,
- Start of distance measurements,
- Stopping the measurements,
- Reading of measurement data,
- Checking readiness of measurement data,
- Sensor reset.

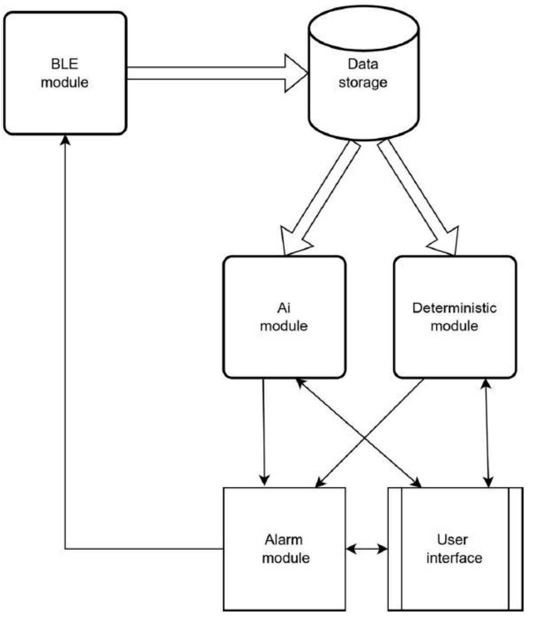

Fig. 6. Application architecture
Rys. 6. Architektura aplikacji

2.5.2. Standard BLE

The BLE transmission standard [A11] will be used in the project to connect parts of the human-worn system (sensors, microcontroller, BLE module) to the smartphone running the application. It provides wireless data transmission with very low power consumption therefore energy saving is realized. The BLE module "wakes up" only for the time of transmission. It usually has a range of several meters, which is perfectly sufficient for this application. BLE supports encryption, pairing and authorization. Sensor data is preprocessed by the microcontroller and then sent to the application only if there are any changes in the data, data that has not changed over time is not transmitted, which further increases energy efficiency. When it happens and still there are no changes (a very rare situation) then a keepalive message is sent, which sustains the transmission and informs the receiver that everything is fine but there is no data to transmit.

2.6. Application

The smartphone application is currently under development and will have a modular design as shown in the Fig. 6.

The BLE module is responsible for transmitting measurement data. It receives data from sensors and stores it in the "Data Storage" module. This module verifies the correctness of the data and fills in missing values that were not transmitted due to a lack of changes, ensuring data completeness and readiness for further analysis. The "Data storage" module efficiently stores distance – related data and provides it to other modules that require it. The "AI module" will uses artificial neural networks to analyse and interpret the environment and recognize situations of interest. Work is currently underway on selecting and developing a neural network model. Training data for the model will come from distance sensors, appropriately interpreted (labelled) by the observer. The "deterministic module" will analyse data with deterministic algorithms to quickly detect anomalies and dangers. The "user interface module" will be used to present the results of calculations in various forms and also to set the parameters of the entire application, including individual modules. The "alarm module" will be designed to transmit alarm information in real time and allows alarms to be transmitted externally via the BLE module. It is easy in the future to expand the application with new modules and to transmit alarms and messages to the user's spatial audio system and haptic devices presenting information in a user-appropriate way. The application can also be connected to an external alert system that notifies about issues or the user's condition, which significantly broadens its potential applications and enhances the safety of those using it.

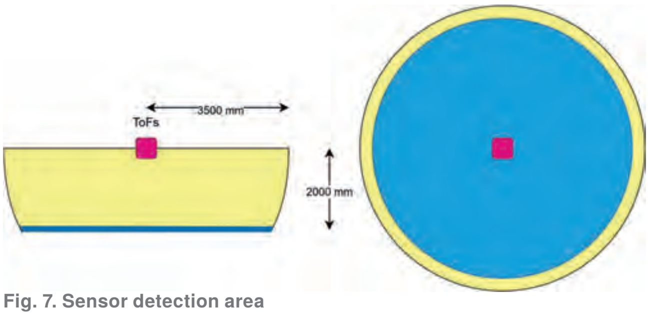

Fig. 7. Sensor detection area
Rys 7. Obszar detekcji czujnika

As previously mentioned, a smartphone application is currently under development. Ongoing work focuses on evaluating and selecting the most suitable neural network model. It is also anticipated that alerts and information for the user will be delivered via the smartphone in the form of visualizations, sounds, and verbal messages, including voice notifications in situations where visual communication may be ineffective (e.g., for visually impaired users, in smoke-filled environments, or when smartphone interaction is not feasible). If, during testing and experimentation, on-device data processing on the smartphone proves to be suboptimal, the approach will be revised – shifting computation to a PC or cloud infrastructure, with the smartphone serving primarily as a data transmission interface.

2.7. Measurement parameters of the system

As previously described and shown in Fig. 1, the system has 16 VL53L5CX sensors arranged in two rows at corresponding angles. Each sensor has a 45° by 45° viewing angle. The arrangement of the sensors allows for 360° × 90° observations of the environment, as schematically shown in Fig. 7. A single measurement gives the distance from the sensor to an object located in the 5.625 ° by 5.625 ° area. The frame rate is 15 Hz and the range is 3,500 mm. The vertical resolution is 16 and the post-zero resolution is 64, resulting in a 16 × 64 array having 65 536 elements.

In Figure 7, the yellow colour represents the 3500 mm range of detection of the sensors (denoted collectively in red). The blue colour represents the ground (floor), which mostly appears in measurements using this system and thus limits the detection area. The arc at the end of the yellow area shows the range of detection.

Figure 8 shows a matrix of measurements, each square corresponds to one element. During measurements, a convenient way to visualize is to fill this grid with the appropriate colours representing the measured distance. The measurement points are numbered vertically from 0 to 15 and horizontally from 0 to 63. The data sent from the sensors for each individual measurement contains the following information:

- Sensor number (0–15),
- Index (0–63),
- Distance (10–3500) [mm],
- Status (see Table 3 for description),
- Signal Strength (0–2048),
- Ambient light (0–1000).

3. Experimental results

The operation of the presented PSOSS system was carried out in a corridor with a width of 2000 mm. The measurement matrix for such a situation is presented in Figure 1.

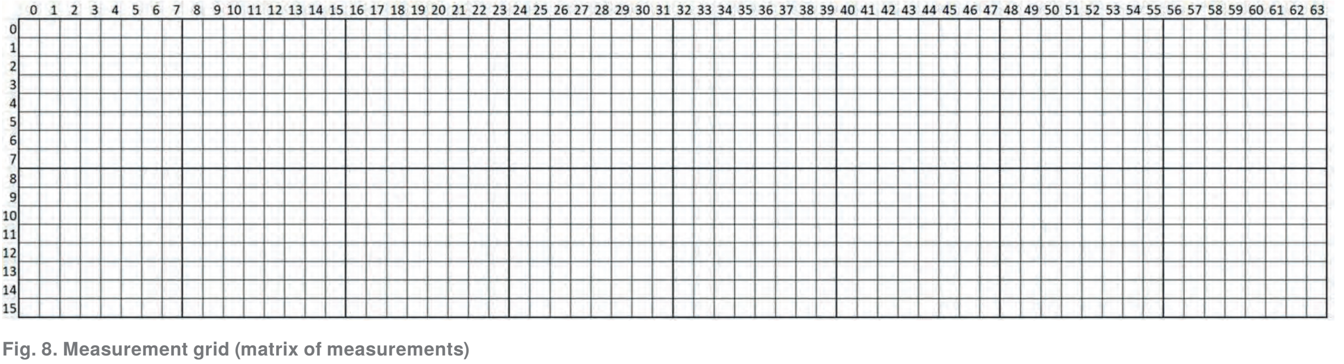

Fig. 8. Measurement grid (matrix of measurements)
Rys. 8. Siatka pomiarowa (macierz pomiarów)

Table 3. Measurement status
Tabela 3. Status pomiaru

Code	Meaning	Description
0	Measurement OK	Proper measurement
1	Signal fail	Excessive uncertainty (statistical error)
2	Signal fail	Too weak reflected signal (e.g., not enough light)
5	Out of bounds	Distance out of sensor range
7	Wrapped target	Reflection too close (interference)
255	No update	No data update

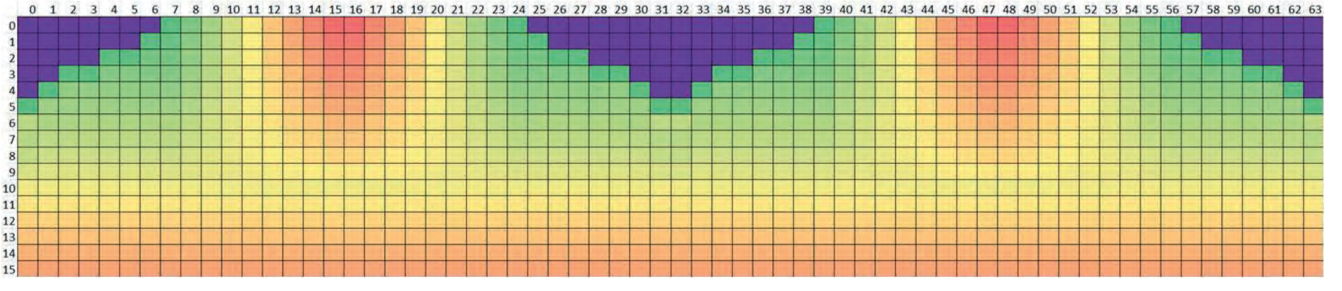

Fig. 9. Measurement matrix for an empty corridor (the colours represent the distance)
Rys. 9. Macierz pomiarowa dla pustego korytarza (kolory oznaczają odległość)

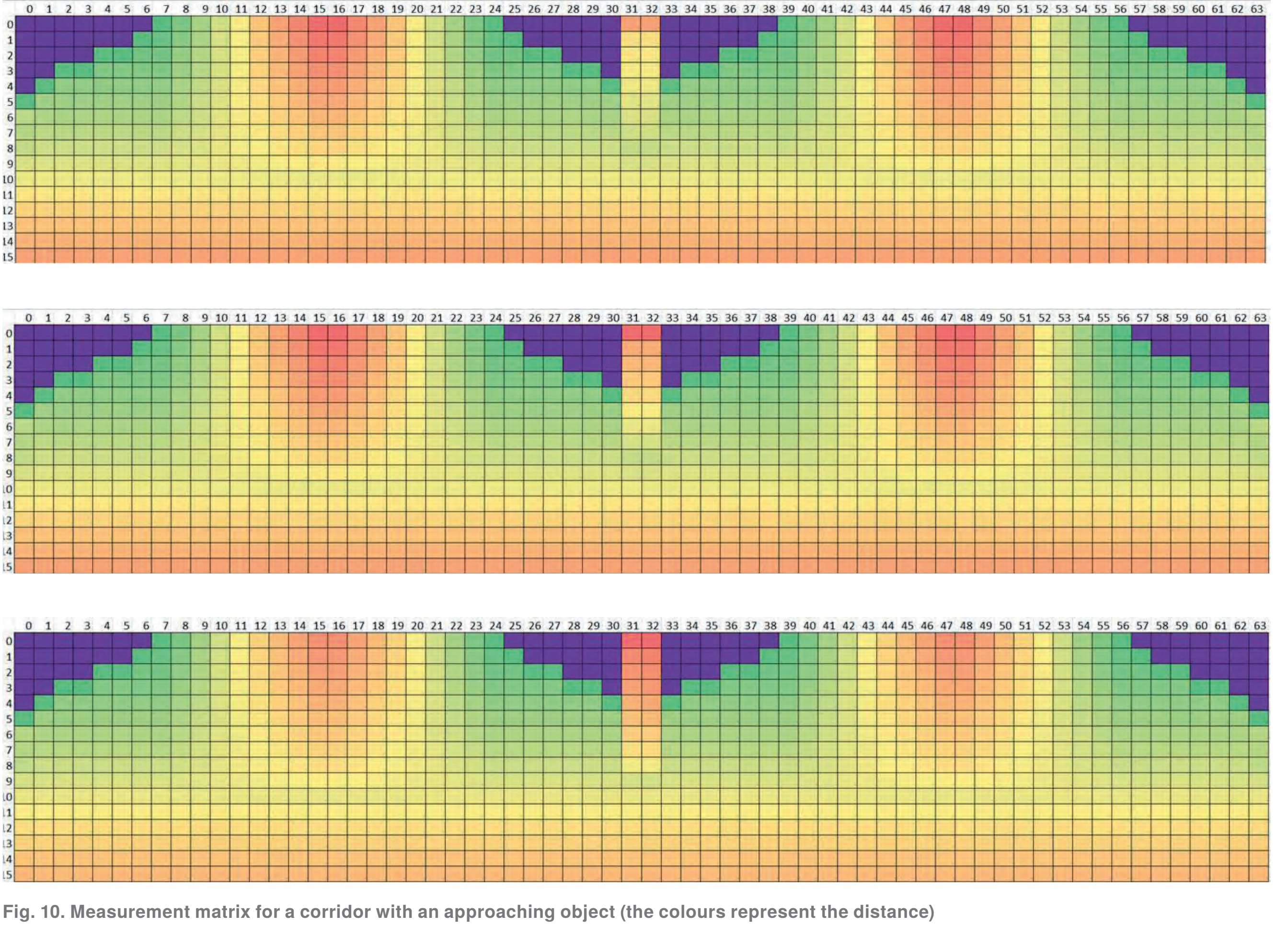

Fig. 10. Measurement matrix for a corridor with an approaching object (the colours represent the distance)
Rys. 10. Macierz pomiarowa korytarza ze zbliżającym się obiektem (kolory oznaczają odległość)

In Figure 9, the purple colour indicates that the measurement range has been exceeded. The colours going from green through yellow to red represent the distances from the farthest (3500 mm) to the nearest.

Figure 10 shows three consecutive measurement matrices (a), (b) and (c) with a central object approaching from the front. Based on comparisons of the measurement matrix, the trajectory and velocity of the object can be determined. This can be seen in columns 31 and 32 on matrices from Figures 10 (a), 10 (b) and 10 (c). The experiment confirmed that the system is able to observe the surrounding. It is possible to track multiple objects at once and ap-proximate shape and dimensions of objects and dimensions of a room within the range of sensors. It is also possible to detect danger – an obstacle, a sudden drop in terrain (such as stairs), other moving objects, etc. The measurement accuracy is about 10 % witch is compatible with the documentation of the chosen sensors. This accuracy is sufficient for this kind of project.

4. Discussion

The article presents a proposal for a spatial orientation support system designed for personal use inside buildings. It is designed primarily for visually impaired people, but can be successfully used by, for example, firefighters in smoky conditions, during could or lack of lighting. The system is based on a set of ToF sensors giving a 360° by 90° "picture" of the environment with a resolution of 16 × 64, or 65536 elements each with an angle of 5.625° by 5.625°. It has a range of 3,500 mm. Sensor data is continuously transmitted to an app located on a smartphone for analysis and interpretation. The app processes, stores and analyses the data to interpret the environment, detects anomalies and dangers. The proposed system is a highly valuable device concept that, in a sense, enhances the sense of vision. The system is currently being developed and tested. It is planned to add additional functionalities such as, among others:

- Notification of user's fall,
- Collision with an obstacle,
- Predictions of trajectories of observed objects,
- Voice information on the status of the environment,
- Taking distance measurements in a given direction at the user's request.

The system aims to improve the safety and independence of people with visual disabilities by providing them with real-time information about obstacles and the structure of their surroundings through audible or haptic messaging. This will be implemented within the alarm module and user interface (Fig. 6). This project has the potential to improve the quality of life of users and increase the safety and efficiency of movement in various environments, while being an innovative technological solution in the field of intelligent navigation systems. It can also be used by various public services (firefighters, police, military) to conduct operations in conditions of limited vision (smoke, fog, lack of lighting). At present, the operational capabilities and performance parameters of the distance sensors have been experimentally validated, as well as the feasibility of acquiring data in the form of a distance matrix representing objects surrounding the user. Ongoing work includes testing and evaluation of individual components of the proposed system concept. Following verification and any necessary modifications to the implemented solutions, the final design of both the hardware and software will be developed.

References

1. Brachmann E., Rother C., *Visual Camera Re-Localization From RGB and RGB-D Images Using DSAC*, "IEEE Transactions on Pattern Analysis and Machine Intelligence", Vol. 44, No. 9, 2022, 5847–5865, DOI: 10.1109/TPAMI.2021.3070754.
2. Wan T., Du S, Xu Y., Xu G., Li Z., Chen B., Gao Y., *RGB-D point cloud registration via infrared and color camera*, "Multimedia Tools and Applications", Vol. 78, 2019, 33223–33246, DOI: 10.1007/s11042-019-7159-6.
3. Maulana I., Rusdinar A., Priramadhi R., *Lidar Application for Mapping and Robot Navigation on Closed Environment*, "Journal of Measurements, Electronics, Communications, and Systems", Vol. 4, 2018, 20–26, DOI: 10.25124/jmecs.v4i1.1696.
4. Roos F., Kellner D., Dickmann J., Waldschmidt C., *Reliable Orientation Estimation of Vehicles in High-Resolution Radar Images*, "IEEE Transactions on Microwave Theory and Techniques", Vol. 64, No. 9, 2016, 2986–2993, DOI: 10.1109/TMTT.2016.2586476.
5. Chellappan N., *Ultrasonic Sensor: Working Principle and Applications*, [www.learnelectronicsindia.com/post/ultrasonic-sensor].
6. Yadav S., *Global Navigation Satellite System (GNNS) Applications: Location, Navigation & Tracking*, [https://geographicbook.com/global-navigation-satellite-system-gnns-applications-location-navigation-tracking].
7. Hassan H.S., Hussein M., Saad S.M., Dzahir M., *An Overview of Local Positioning System: Technologies, Techniques and Applications*, "International Journal of Engineering and Technology", Vol. 7, 2018, DOI: 10.14419/IJET.V7I3.25.17459.
8. Collignon O., Voss P., Lassonde M., Lepore F., *Cross-modal plasticity for the spatial processing of sounds in visually deprived subjects*, "Experimental Brain Research", Vol. 192, No. 3, 2009, 343–358, DOI: 10.1007/s00221-008-1553-z.
9. Proulx M., Ptito M., Amedi A., *Multisensory integration, sensory substitution and visual rehabilitation*, "Neuroscience and Biobehavioral Reviews", Vol. 41, No. 1–2, 2014, DOI: 10.1016/j.neubiorev.2014.03.004.
10. Maidenbaum S., Abboud S., Amedi A., *Sensory substitution: closing the gap between basic research and widespread practical visual rehabilitation*, "Neuroscience and Biobehavioral Reviews", Vol. 41, 2014, 3–15, DOI: 10.1016/j.neubiorev.2013.11.007.
11. Zhou M., Liu Y., Liu X., Li M., Qian W., Li N, Ke B., *A wearable real-time tactile-vision substitution system: clinical validation for spatial navigation and quality of life in blind people*, "Displays", Vol. 93, 2026, DOI: 10.1016/j.displa.2026.103400.
12. Shan-Yuan T., Gene K., Xuanyou L., Lopes P., *Seeing with the Hands: A Sensory Substitution That Supports Manual Interactions*, 2025, DOI: 10.1145/3706598.3713419.

Other sources

A1. Douglas B., *Fusing a Mag, Accel, and Gyro to Estimate Orientation/Understanding Sensor Fusion and Tracking*, [www.mathworks.com/videos/sensor-fusion-part-2-fusing-a-mag-acceland-gyro-to-estimate-orientation-1569411056638.html].

A2. Time-of-Flight (ToF) 8×8 multizone ranging sensor with wide field of view, [www.st.com/en/imaging-and-photonics-solutions/vl53l5cx.html].

A3. VL53L5CX Datasheet, [www.st.com/resource/en/datasheet/vl53l5cx.pdf].

A4. VL53L5CX Time-of-Flight 8x8 multizone ranging sensor with wide field of view, [www.st.com/resource/en/flyer/vl53l5cx_flyer.pdf].

A5. AN5717 Application note. How to setup and run the VL53L5CX-SATEL using an STM32 Nucleo64 board, [www.st.com/resource/en/application_note/an5717-how-to-setup-andrun-the-vl53l5cxsatelusing-an-stm32-nucleo64-board-stmicroelectronics.pdf].

A6. VL53L5CX-SATEL Schematic and list of materials, [www.st.com/resource/en/data_brief/vl53l5cx-satel.pdf].

A7. STM32 Dynamic Efficiency MCU, Arm Cortex-M4 core with DSP and FPU, up to 512 Kbytes of Flash memory, 84 MHz CPU, Art Accelerator, [www.st.com/en/microcontrollers-microprocessors/stm32f401re.html].

A8. Time-of-Flight (ToF) 8×8 multizone ranging sensor with wide field of view – Tools & Software, [www.st.com/en/imaging-and-photonicssolutions/vl53l5cx.html#tools-software].

A9. ST67W611M1 Low-power Wi-Fi 6 – Bluetooth® LE combo coprocessor module ST67W611M1 Datasheet, [www.st.com/resource/en/datasheet/st67w611m1.pdf].

A10. Ultra Lite Driver (ULD) for VL53L5CX multi-zone sensor, [www.st.com/en/embedded-software/stsw-img023.html#overview].

A11. Technical document: Bluetooth Low Energy 5.0, [www.utac.com/wpcontent/uploads/2023/04/SECUR-WP2-D2.1-Technical-Document-Report-Bluetooth-Low-Energy-5.0.pdf].

Koncepcja systemu wbudowanego wspomagającego orientację przestrzenną z czujnikami ToF

Streszczenie: W artykule przedstawiono zarys koncepcji systemu wbudowanego, który jest projektowany do wspomagania orientacji przestrzennej zarówno osób z dysfunkcją wzroku, jak i służb ratunkowych (np. strażaków) działających w warunkach ograniczonej widoczności, takich jak zadymione lub ciemne obszary. System Wspomagania Orientacji Przestrzennej Osobistej (PSOSS) wykorzystuje szesnaście czujników odległości opartych na pomiarze czasu przelotu (ToF) rozmieszczonych wokół użytkownika, umożliwiając pomiar odległości we wszystkich kierunkach. Dane z czujników będą przetwarzane przez sztuczne sieci neuronowe, które klasyfikują przeszkody i szacują ich względne położenie. System będzie dostarczał w czasie rzeczywistym informacji o odległościach i ruchu obiektów. Proponowany system może znacząco zwiększyć bezpieczeństwo i niezależność użytkowników w różnych środowiskach, stanowiąc innowacyjny krok w kierunku inteligentnych pomocy nawigacyjnych dla osób z dysfunkcją wzroku.

Słowa kluczowe: inteligentne systemy orientacji przestrzennej, system wbudowany, czujniki odległości czasu przelotu (TFT), sztuczne sieci neuronowe

Marta Szymczyk, MSc Eng.

mszymczyk@agh.edu.pl
ORCID: 0009-0007-0679-2407

Graduate of the AGH University of Krakow, holding an Engineer's degree in Electronics and Telecommunications and a MSc degree in Teleinformatics. Currently a PhD student in Biomedical Engineering at the AGH Doctoral School. Active member of the Real--Time Systems Research Group at AGH, contributing to a research project focused on the performance, reliability, and security analysis of an innovative self-organizing BLE Mesh network system designed for biomedical sensor applications.''.