[redacted] sensor network to gather data on sports activities in public space

Author: [redacted] AMS Institute, November 5th 2020

Our understanding of requirements

The Sportakkoord Challenge Buitenruimte is looking for a solution that gives insight in outside sports activities. Where, when, and how often do people engage in walking, running and cycling. The minimum requirement is to estimate the number of people in a particular area. It is of great importance that the privacy of persons is respected and the solution complies with the GDPR.

Description of solution

We propose a network of millimetre wave sensors, distributed through a demarcated area of public space.

The millimetre wave technology is commonly used in cars for i.e. parking assistance. It is a sensing technology that works like a radar, which sends signals and receives the reflections from the objects of interest. Moving objects are registered as a collection of dots. The only information gathered is the range, velocity and angle of these objects.

We are developing a stand-alone sensor with mmwave technology at its heart. We connect this sensor to a machine learning algorithm, which runs on the device, and uses this input data to distinguish between different persons, and can be trained to distinguish between pedestrians, people running and cycling. The device will further contain a solar panel, power module, battery system and wireless communication module to connect to a server.

The viewing area of a typical millimetre wave sensor is 7 by 20 meters. By installing these at key points in public space, and connecting them to a central server, it is possible to gather insight on sports activities in public space.

Features

- Designed to be privacy proof, **beyond GDPR requirements**
  In collaboration with legal experts and tech developers, our ambition is to develop a system that does not collect any type of personal data This is a **key advantage compared to other solutions** in the market, such as those based on cameras, where the sensor gathers personal data (images), which at best, is afterwards anonymized according to GDPR-compliant standards. This way of working has been proven susceptible to personal data leaks or break ins. . At present, various Municipal Privacy Officers have stated that the device either already meets this criterion, and is a significant improvement over alternatives.

- **No cable connections**
  Because the software and hardware are developed for low power usage, the final device will be powered with a solar panel and an on-board battery. The data connection is wireless. This

means that there is **no need for cable connections.** This greatly facilitates deployment and redeployment of the sensors. Sensors can be moved to different locations to cover more ground over time.

- **Human friendly design**
  Typically, sensors in the public space have not been designed for humans. At best, their casings are designed to protect the sensors from severe weather conditions, such as rain; and these "black sensing boxes" do not reveal what they measure, on whose behalf, and why. As audiences are growing increasingly more aware about the risks associated with digital technology (privacy, algorithmic bias, news bubbles, facial recognition cameras), we think that designing sensors as 'black boxes' will ultimately lead to public distrust of sensors. Together with the a design firm and the TU Delft Faculty of Industrial Engineering Design, we are working on a design that is aesthetically pleasing, and intuitively understandable to passers-by.

- **Affordable**
  As we are developing this sensor as open source technology (more information about this is provided in the market model), we expect the devices to be affordable (approx. 350 euros per device), which will facilitate the uptake of this sensing technology.

Current status of technology

The Embedded and Networked Systems (ENS) group at TU Delft has develop the initial proof of concept in the master Thesis of [redacted] In this proof, the device could count numbers of persons, and distinguish between adults, children, and people using bikes.

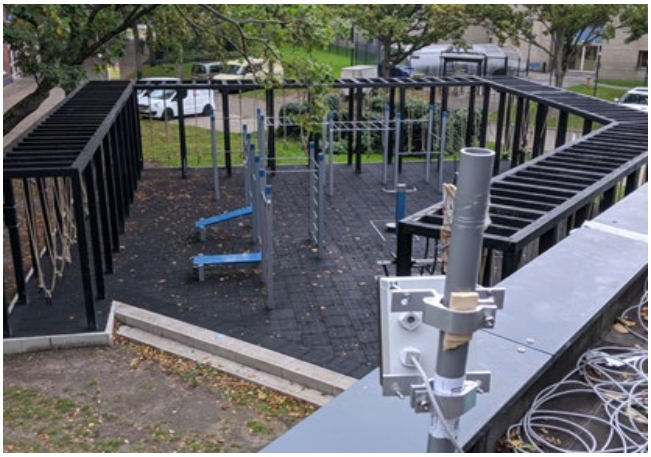


The current consortium consisting of the AMS Institute, TU Delft, Beep-Beep and the Municipalities of Amsterdam and Rotterdam, have developed an outdoor version of the sensor. This platform is currently being tested at the Marine Terrain Living Lab in Amsterdam (see pictures below. A first version of the User Interface Design for the sensor is being developed by a design firm with the main goal of designing a sensor that people can understand and trust.

Our findings indicate that the technology is promising, but more work is needed on both the soft and hardware part to achieve the desired reliability and accuracy under different weather conditions.

Market model

We believe in fair digital technology. We want to move away from an ecosystem dominated by large private corporations shaping our digital future, gathering personal data, or offering expensive services and products to public organizations that have little control over.



For that reason, we develop our technology as open hardware and software under a license that allows commercial use. By developing an open platform, we allow other parties to build their own services and products. As the ' heavily lifting' of the hardware and algorithmic development will be done by us, we will lower the barrier for service providers to enter this market, leading ultimately to a better product/service and lower price for public customers (gebiedsbeheerders such as Staatsbosbeheer, gemeenten etc.) The open license approach has additional advantages: it allows gebiedsbeheerders the possibility of not buying this service but doing it for themselves. Open source licenses also allow the creation of wider communities contributing to the project.

However, *somebody* needs to make use of the groundwork that we are building and turn it into a useable turn-key solution. Beep-beep, our tech partner, will function as a 'launching seller', designing, producing and selling sensors + dashboards based on the open source foundations. Consortium partners Amsterdam, Rotterdam and the TU Delft (for crowd sensing at campus) have indicated an interest in buying this solution.

In addition to this we will raise the interest with other commercial technology providers to adopt our open source foundation in their products and/or services. This in turn will lead to an increased market for digital sports measurement tools.

Plan of approach

In the coming year, we need to work on software, hardware and interface development.

Software development

Task 1: Porting code to resource constrained platforms. Currently, mmwave sensors run on platforms with significant resources in terms of computational power and energy. To have a sensor running on solar panels, we will need to modify the code to run in constrained platforms.

Task 2: Improve accuracy to count people. The presence of dynamic objects or metallic surfaces (e.g. motorbikes, wind blowing the branches of trees, etc) could be confused with people. The algorithm will need to be fine-tuned to filter out noise sources.

Task 3: Work on machine learning methods for sports activity classification (running, walking, cycling). Our algorithm recognizes if a moving element is an adult or kid, but we need to expand it to recognize different types of sport activities.

Hardware development

Task 4: Improve power management. To rely solely on a small surface of solar panels, we will need to minimize the energy cost of different components. The aim is to use solar panels of approximately a 50cm x 50cm area.

Task 5: Improve antenna reception. MMwave sensors work better indoors, where there is no need to cope with stringent weather conditions. We will need to test different casings and antenna configurations to make sure the system works reliably outdoors.

Interface development

Task 6. Develop user friendly casing. The casing of the sensor will need to be designed to be aesthetically pleasing and informative, so citizens trust their deployment.

Task 7. Dashboard. A intuitive dashboard with a clean API will be developed so the sporting information can be presented in multiple ways, from basic (time-charts, pie-charts, heatmaps, etc.) to advanced (for example, depicting "flows of people" across a city to monitor its health/activity level)

Legal & market

Task 8: Get additional legal feedback to resolve question whether sensor legally falls outside of GDPR (does not collect personal data from scratch.

Task 9: Develop marketable product / service proposition. Also approach other possible vendors interested to build on open source part of system.

Testing

Task 10: At the AMS Institute we have access to the Marine Terrain Living Lab area. This area, located in the center of Amsterdam, is ideal to develop such technology because it is an actual outdoor environment which is frequently used for sport activities (jogging etc.). Due to the ownership structure of the terrain (it is private, but publicly accessible), we can deploy and test sensors more quickly than in other parts of the city, where local regulations apply. Furthermore, since the area covered by the living lab is big, it will allow us to test how the information coming from multiple devices can be fused to provide a bigger picture of how large public areas are used for sport activities. Contacts are ongoing Amsterdam Sports department, which has shown an interests in this system.

Planning

Jan 1, 2021	Month 1-4	Months 5-8	Month 9-12	Dec 31, 2021
	Task 2: Accuracy algorithm	Task 1: Porting code	Task 6: User interface / casing	
	Task 3: classification sports types	Task 4: Improve power management	Task 7: dashboard	
	Task 8: GDPR legal second opinion	Task 5: Improve antenna reception	Task 9: Develop product / service proposition	
	Task 10: testing indoors and at Marine Terrain			

Team

AMS Institute [redacted])	Research Organization	Project management, Legal, Interface design
Amsterdam Municipality [redacted])	Public organization	Testing, city as user perspective
TU Delft [redacted])	Research Organization	Software development & testing
Beep-Beep [redacted])	Tech Startup	Hardware, production

AMS institute will act as a the lead subscriber.

Budget

Budget demand			**Budget coverage**	
Software engineering	[redacted]		Sport innovator challenge	[redacted]
Hardware engineering	[redacted]		AMS-Institute	[redacted]
Interface & Design	[redacted]			
Electronic & mechanical components	[redacted]			

Amsterdam Institute for Advanced Metropolitan Solutions

Kattenburgerstraat 7, building 027W, 1018 JA Amsterdam

T +31 [redacted]
www.ams-institute.org
[redacted]
Kvk: 61346020