ISSN 1533-9211

DOI 10.5281/zenodo.6973926

REAL TIME ENVIRONMENT MAPPING USING SENSOR AGGREGATION NETWORKS

[1]Dr. ANALA M.R, [2]AMITH R and [3]NINAAD RAO

[1]Professor at RV College of Engineering.
[2,3]M Tech in Information Technology, R V College Of Engineering.

Abstract

Advent of computer vision and machine learning algorithms in the field of data science have encouraged development of intelligent systems incorporating simple hardware and software processing techniques and one such area of research is into virtualization of the physical environment using real time object detection and mapping techniques. The domain of object detection and classification is one that has a diverse variety of applications ranging from collision avoidance, virtual reality gaming, augmented reality, education, healthcare and so on. The purpose of this paper is to identify intelligent sensor systems and aggregations of object detection techniques, with the goal of understanding how each individual sensor works independently and as a subcomponent of a larger complex sensor aggregation system capable of generating a depth map of its surroundings. The research also tries to establish a critical list of applications that make use of sensor networks, as well as the complexity of constructing them.

1. INTRODUCTION

Sensor Network systems combine the use of different types of sensors placed at geographically separated or clustered points depending on the environment and nature of use. The sensors can be placed at geographically separated locations collect information and transmit the data to a processing station where information filtering, precalculation measures are taken and then the aggregated information is utilized for surveying or observation purposes. There is immense number of challenges as far as implementation of these sensor networks are concerned, some of them being mainly dealing with complexity of the sensor system itself, due to the fact that there are terabytes of calculations needed and the entire system is always vulnerable to external factors. For instance, in a large area when the nodes are widely distributed every node should be able to communicate to the base station and if the bandwidth is low then there can be loss of information. Hence, efforts have to be made such that the system can be deployed easily ensuring its steady maintenance over a persistent period of time.

In the proposed methodology Omni directional cameras, IMUs LIDAR, and Ultrasonic sensors are used for tracing purposes. Under various environmental conditions the camera and ultrasonic sensors tracing performance varies even when they are tracing the object simultaneously. The accuracy of the system is dependent on the design and the individual node

2. LITERATURE SURVEY

The author [1] has presented a technique for real-time object tracking utilising the WSN paradigm, in which the sensor node uses camera and distance sensors for object recognition and an efficient tracking algorithm is added for real-time object tracking. Sensors continually track the location of the object, and coordinates are sent to the base station in real time. The

ISSN 1533-9211
DOI 10.5281/zenodo.6973926

system nodes are always active for object detection, however wireless communication between the sensor node and the base station is only performed when the target object's position changes. For communication between nodes and base stations, the proposed sensor network design and diverse object trajectories and environmental conditions, the suggested method is tested for indoor object tracking, and a comparison study of camera and distance-based tracking is performed.

The number of successfully received data packets at a sink is compared to the number of data packets calculated by applications for reliable detection in existing research to assess detection reliability of an individual object. A continuous object, unlike discrete items, could cover a large area and dynamically change its shape in response to physical conditions such as wind, geographical features, and so on. As a result, the indication for individual objects cannot be used to determine the continuous object detection reliability. The author [3] defines a new reliability indicator for continuous object detection. Then, based on the estimation result from the novel indicator, it suggests an error recovery and revision strategy. The suggested approach delivers good reliability in terms of continuous object detection, according to simulation findings.

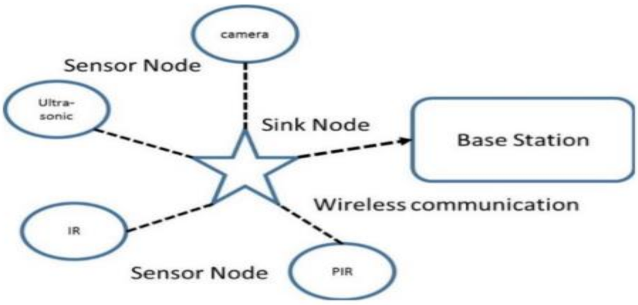
Sensors typically manage multi-mode operation, in which they alternate between active and inactive states on a regular basis to save energy. Between object detecting precision and energy efficiency, there is a compromise. Different sensing schedules should be used depending on the object speed, direction, and sensor deployment topology. In this research [4], the author presents a unique RNN-based sensor dynamic duty cycle control approach for determining each sensor node's best sensing schedule. The suggested approach achieves great energy efficiency and delivers accurate object recognition, according to simulation findings.

3. METHODOLOGY

The Methodology from paper [1] is used for understanding with the help of three algorithms. The figure depicts the WSN architecture used for real-time object tracking. In the sensor network system, where heterogeneous sensor nodes are wirelessly coupled to a sink node/base station, the suggested methodology employs star topology. The sensor nodes use various sensors to identify objects and deliver the collected data to the sink node. The position of an object is known if any sensor detects a moving thing in its proximity. The coordinates of the detected object are communicated to the base station, and the trajectory of the target object's path is received at the base station end. When an object leaves one node's detection range and enters another node's detection zone, the other node becomes active and begins tracking the object. The target object is thus continuously monitored in a wireless sensor network, with a near-zero miss rate.

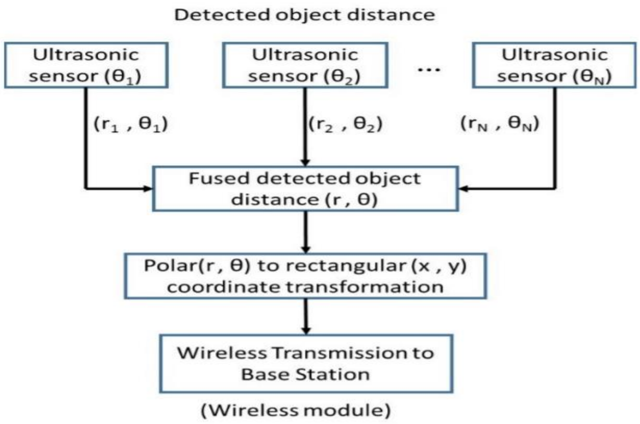
Fig 3.1: Sensor Network using Wireless Architecture

ISSN 1533-9211
DOI 10.5281/zenodo.6973926



The sensor nodes collaborate to improve overall detection coverage. Furthermore, the network's lifetime is preserved since not all nodes communicate with the sink node all of the time; rather, only active nodes communicate with the sink node. As a result, the WSN structure proposed uses the least amount of energy. The flowchart of Fig. 2 depicts the functioning of the proposed object tracking approach in the paradigm. The following sections go through the specifics of how the camera and ultrasonic sensor nodes work. The ultrasonic sensor node is made up of an array of ultrasonic sensors, each of which is oriented in a specific way (line of sight). The ultrasonic sensor array is built with overlapping detection zones with consecutive "N" individual sensors positioned at pre-defined angular points to give extensive coverage of the monitoring region, as shown in Fig. 4. The node is based on the concept of deriving polar coordinates (r,), where the component r is derived from the ultrasonic sensor value and is constant for each ultrasonic sensor. When an object approaches each sensor, it is detected. The ultrasonic sensor value and its accompanying polar coordinates are used to determine the polar coordinates. The average value of two ultrasonic sensors and their accompanying average angles are combined to determine the fused polar coordinates of the object location if the object enters the overlapping zone of two consecutive sensors.

Fig 3.2: Ultrasonic Single Node Sensor Working



4. IMPLEMENTATION

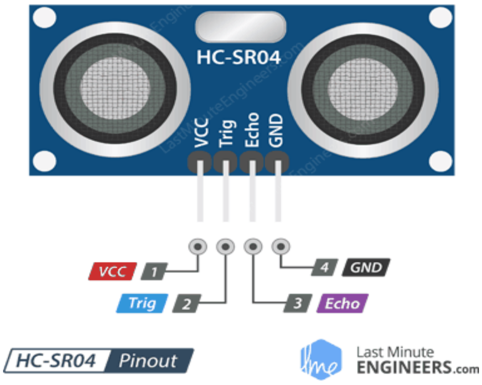
ISSN 1533-9211

DOI 10.5281/zenodo.6973926

The Sensor aggregation network for virtual mapping can be implemented using the following components:

Ultrasonic Sensors: Ultrasonic sensors are close range sensors and can be easily mounted at various access points in the system. These sensors send out ultrasonic waves travelling at speed of sound, thus making them ideal candidates for short range object detection and mapping. They are hence used typically in self-parking systems and close range surface mapping systems. The sensor sends out signals of sound waves every few microseconds and analyses the shift in the reflected sound wave, thus effectively determining close range object distances to stunning levels of accuracy. The major advantage of these sensors includes low latency and implementation costs.

Fig 4.1: Close Range Object Detection-Ultrasonic waves



LIDAR: The ultrasonic sensors are effective and responsive with only close-range obstacles, and cannot perform well when it is necessary to track distant objects of the range 6m to 200 m. Also, the speed of sound waves are way much less compared to light waves, and hence another system is necessary to be integrated called as LIDAR

Fig 4.2: Long Range object tracking using LIDAR

The motive of using LIDAR is long range detection, and unlike sound waves light travels a million times faster than the speed of sound, thus accounting for better responsiveness and accurate tractability. LIDAR is also effective in tracking fast moving objects thus sensor information obtained adds a great value.

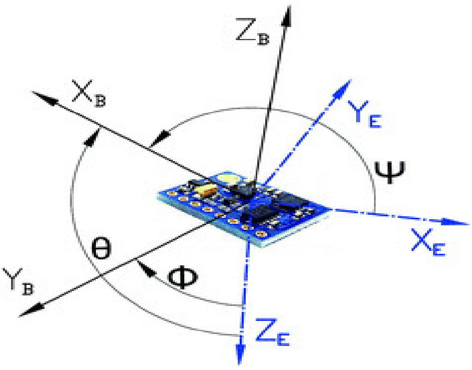
ISSN 1533-9211
DOI 10.5281/zenodo.6973926

Omnidirectional Camera: As with most autonomous systems, it is important to have a visual understanding of the environment and once the framework is established using aggregated information from the distance mapping algorithms, and to do this an omnidirectional camera module is utilized which has a 360-degree field of view. Once the images are obtained, image processing algorithms such as Mack-RCNN can be used to identify different objects and tag them. The tagging can also represent multiple parameters such as fragileness of an object, structure, dimension related information and so on. This helps develop a better understanding of the surroundings.

Fig 4.3: Object Detection using Omnidirectional Camera

Inertial Sensors on Device: The system emphasizes on the fact that it is not sufficient to just survey the surroundings but also to measure and analyze the state of the sensor system as a whole. The state of the system is calibrated and measured using sensors such as gyroscope, pressure sensors, accelerometers, magnetometers and so on.

Fig 4.4: Inertial/Motion Sensors

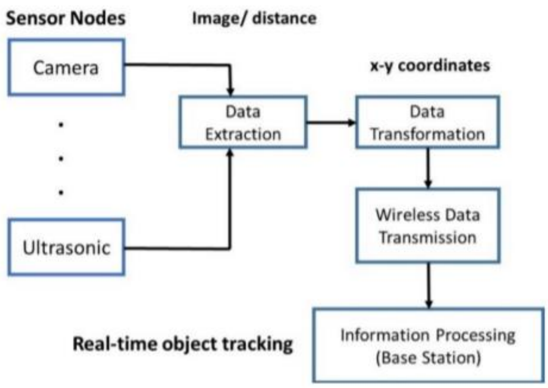


These sensors typically help analyse the state of the system and helps establish a better understanding about the orientation of the plane or the environment in which the system is placed in. a typical example would be a level sensor which detects a vehicle if it is tilted beyond 60 degrees and immediately alerts the fire/health/police department or it could be magnetometers which provide the global positioning location of a system.

ISSN 1533-9211
DOI 10.5281/zenodo.6973926

Aggregating sensor information: The information obtained from different measurements is diverse in behavior as well as timing in which the data is supplied to the processing node from the sensory link node. There may be delays, staggered information feedbacks which occur at different frequencies and the sensors themselves may be spread out geographically far from each other and from the base station where usually the processing is carried out. Suitable algorithms process the data and validate the same to arrive at a virtual map.

Fig 4.5: Aggregation of Collected Data



All these factors have to be accounted whenever sensor network data is being aggregated and suitable algorithms and filters need to be employed to handle the data as intended. As these are usually critical systems or real time systems, their timeliness and accuracy plays a major role in determining the successful outcome of implementation.

5. APPLICATIONS

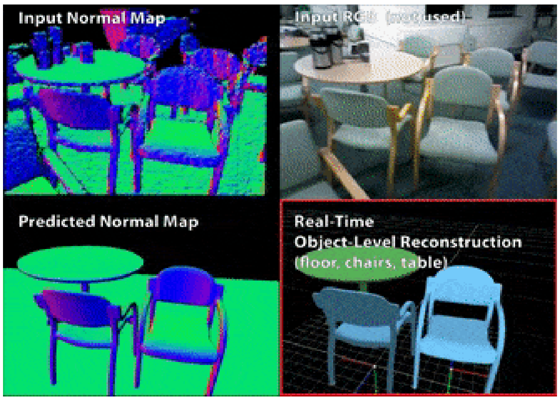
Aggregated Sensor network can be used in a variety of applications. Some of the applications are given below.

VR Technology: This system can not only be used in critical safety systems but also it can be used in entertainment industry as well. VR Technology can be enhanced by implementing this system in order to make the user experience of the Virtual Reality system better by tracking the position of the user and manipulating the virtual environment accordingly which eliminates the need for handheld controls and thereby making the user experience more immersive.

ISSN 1533-9211

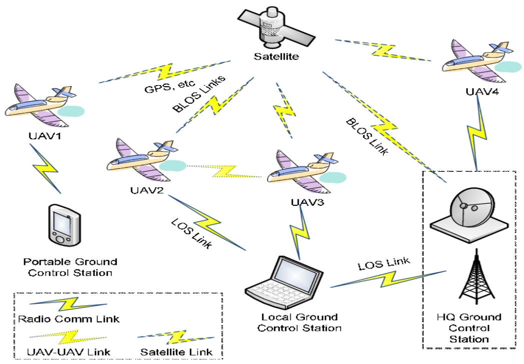
DOI 10.5281/zenodo.6973926

Fig 5.1: Object Mapping using VR



Drone Navigation: Unmanned drones or UAV can use this network in order to map the surrounding objects. This system can be used in military in order to detect enemy vehicles as well as it can be used to explore locations which are very dangerous for humans to explore, and in other rescue operations as well. Some other applications also include intelligent drone surveillance systems used by defense departments where it is used to map cultivated fields for its analysis.

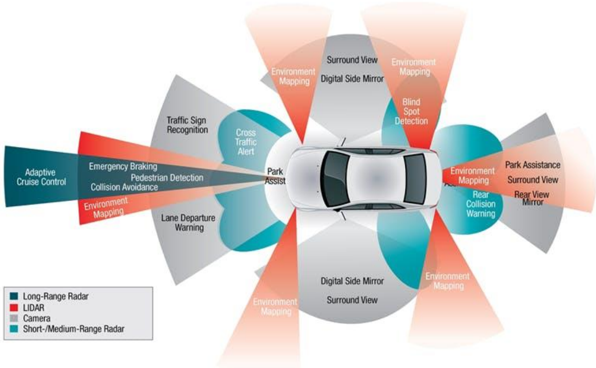
Fig 5.2: UAV Guidance and Navigation System



Weather Forecasting: This sensor network can be implemented in weather forecasting. Sensors can not only be limited to Ultrasonic sensors, LIDAR Sensors and camera sensors, but it can also add additional sensors like Temperature Sensor, Atmospheric Pressure Sensors and Humidity Sensor as well in order to predict the weather. These types of systems are also useful to observe environmental changes over persistently long period of time such as analysis of change of landscape, effect of climate on geographical features of a location.

The Seybold Report
ISSN 1533-9211
DOI 10.5281/zenodo.6973926

Fig 5.3: Autonomous Vehicle Navigation System

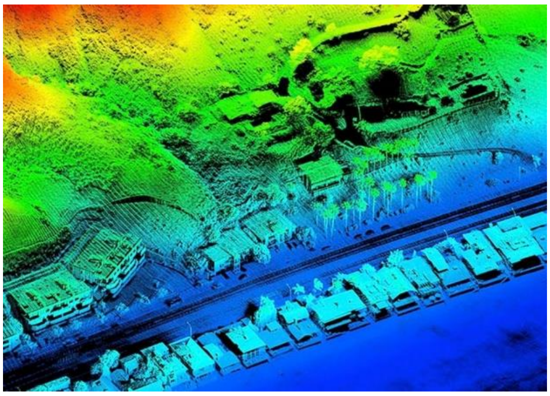


Autonomous Vehicles: Aggregated sensor networks can be used in autonomous vehicle driving as well. Sensors are used to measure the distance between the nearby cars, and also track the cars which are further away. ML models can be applied as well to classify and identify the different objects in the surroundings.

6. CONCLUSION

The sensor aggregation network for detection of objects and mapping the real world environment to the virtual environment is a necessary entity in today's world of digitization. Through the application of this we are able to get a 3D map view of the whole area which contains the objects and we can accurately measure the size and distance of the objects in question.

Fig 6.1: 3D Rendered Model Using Sensor Networks



The scope of the above mentioned sensor aggregation system can be enhanced further by including additional sensors, but the complexity and scalability of the system is something to be kept in mind. Through generalistic synchronization measures and optimisation techniques it is possible to build a suitable model for monitoring and mapping the real world and changes associated with it, with the interest of developing intelligent systems to serve mankind better.

The Seybold REPORT
ISSN 1533-9211
DOI 10.5281/zenodo.6973926

References:

1) Alessio Turetta; Yousseffessaouari, “Cooperative Underwate and Offshore dataacquisition using multiple underwater sensor networks”, IEEE/OES Conference for Autonomous Underwater Vehicles, IEEE Conference 2019.

2) Zool.H.Ismail;KarlSammut, “Autonomous Ship hull inspection by omnidirectional cameras path and view”,IEEE/OES Conference for Autonomous Underwater Vehicles, IEEE Conference 2019.

3) Yeon Jun Choi;InhwanLeee, “Sennsor Data management in Sensor Networks For Low Power”, IEEE conference On Advanced Communication technology, 2018.

4) K.T Ilayaraaja, V. Vijayakumar, “Object Recognition in moving vehicles using deep neural networks”, ICAIS 2021.

5) Indrajit S Achcharya;Sivakumar sivaramakrishnan, “Software Defined Sensor Networks Towards Flexible Architecture Supported By Virtualization”,IEEE Global IoT Summit conference, 2019.

6) Chenhe Li;GhadaBadawy, “LEMOnet: Low Energy wireless sensor networkfor data central monitoring”, IFIPNetworking Conference, IEEE 2019.

7) Hai Zhu; Chenghang Li, “Low-cost topology control for data collecting in duty-cycle wireless sendor networks”, IEEE 18th International Conference on Industrial Informatics, 2020.

8) JianjunWen;WaltenegusDargie, “A simple Clustering Strategy for wireless sensor strategy”, IEEE Sensors letters, 2020.

9) Inh-sikweon;Jae-kwan-Ryu,“Object Edge Recognition Based Interpolation With 3D Lidar and vision for autonomous driving”, IEEEsection on big data technology and applications in intelligent transportation, 2020.

10) Prajwal V R, “Vehicle Detection and Collision Avoidance in Hari pin curves”, IEEE pune section International Conference, 2020.

11) MobeenShahroz;Arif Mahmood, “IoT-Based Smart Shopping Cart Using RFID”, 19th IEEE international conference for information and communications technology, 2020.

12) Lin Zhu; Haoran Wei, “Arbitrary-Oriented Object Detection in Remote Sensing Images Based in Polar Coordinates”, IEEE International conference on Intelligent communication systems, 2020.

13) Yong Huang;Jian Guan, “Arbitrary-Oriented Object Detection in Remote Sensing Images Based in Polar Coordinates”, IEEE Journal For Applied Earth Observations and remote sensing, 2020.