VigiWheels

Project Plan

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Abstract

In an industrial environment, worker safety is of primary importance, and early detection of dangers is essential to prevent accidents. This paper aims to concisely plan the development of an autonomous safety vehicle designed to monitor industrial environments and read analog sensors in order to identify hazard thresholds and track environmental variables to minimize the risk of accidents, including fires, intrusions, and disruptions in the autonomous production chain.

The vehicle's autonomous capability allows it to move precisely in the environment, collecting data continuously by capturing images using image processing and machine learning techniques, analyzing the data in real time to detect any anomalies that could indicate potential damage while performing periodic inspections, as well as having a communication system that informs personnel in case of any danger.

In conclusion, the implementation of an autonomous vehicle for the monitoring and detection of danger thresholds is a significant and useful advance in industrial safety preventive maintenance. Its ability to detect damage early not only helps to prevent manual monitoring costs but mainly safeguards the physical integrity of employees.

Keywords

Autonomous car
Smart patrol
Fire detection
Manometer
Indoor security
ROS
Alert
Mapping
Intruder detection
Production chain
Monitoring
Automation
Industrial safety
Control system
Data analysis
Environmental sensors
Predictive maintenance
Intelligent monitoring
Abnormal activity detection
Driverless technology
Real-time monitoring
Machine learning algorithm
System integration
Smart alarm system
Risk management
Intelligent security platform
Supply chain analysis
Quality control
Production management
Real-time tracking and locating system

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1. Executive summary

1.1. Product description

Ensuring the security of your company's buildings is paramount. This includes conducting surveillance rounds, detecting potential fire incidents, and preventing unauthorized access. To meet these needs, we introduce VigiWheels, a compact autonomous vehicle designed to patrol your premises and perform various tasks to maintain the security of your facilities.

VigiWheels conducts intelligent rounds within your premises. It is equipped to detect specific abnormalities such as glass breakage and unusual sensor readings. If a window is broken or if a sensor reports an abnormal value, VigiWheels will promptly alert the staff and employees. In the event of a fire or detection of an intruder, it also sends out immediate alerts.

In today's world, security solutions are often decentralized, leading to high costs for security equipment. VigiWheels offers the perfect centralized solution for your company, available at any time and every day. No human intervention is necessary, ensuring a fast response in case of an emergency.

With VigiWheels, you can rest assured that your company's security is in good hands.

1.2. Stakeholders

1.2.1. Real stakeholders

Name	Position	Role	Contact information	Influence
Elodie Chanthery	Teacher	Coordinator	echanthe [at] insa-toulouse.fr	High
Sébastien Di Mercurio	Engineer	Coordinator/Equipments supplier	dimercur [at] insa-toulouse.fr	High
José Martin	Engineer	Equipements supplier	jmartin [at] insa-toulouse.fr	Medium
Guillaume Auriol	Teacher	Supervisor / Customer	sebastien.delautier [at] atos.net	High
Alexandre Huyghe	Engineer	Supervisor / Customer		High
Barbara Moore	Teacher	Advisor	bmoore [at] insa-toulouse.fr	Medium
Thibault Lesur	Teacher	Advisor	thibolesur [at] gmail.com	Medium

1.2.2. Fictitious stakeholders

Name	Role	Influence
Firm (Security Staff, Quality Manager, Employees)	User	High
Technology suppliers	Manufacturers	Medium
Government	Legislators	High
Insurance agencies	Insurers	High

1.3. Features

Priority	Name	Description	Categories
1	Indoor Car Navigation	**Guide the car from point A to point B, all while maintaining the ability to track its position within the indoor environment** **Sensors :** LiDAR, inertial station	Indoor Navigation
2	Detecting and Avoiding Obstacles	**Make the vehicle capable of spotting obstacles, recognizing them, and avoiding them** **Sensors:** Ultrasonics, LiDAR, Camera	Obstacle detection
3	Instrument Reading	**Enable the vehicle to read and, most importantly, interpret sensors along its path to ensure building safety** **Sensors:** Camera	Data Processing and Analysis
3	Fire Detection	**The GEI car must be able to detect a fire in a building throughout its patrol. This includes the ability to spot the presence of a developing fire or abnormal heat source and trigger appropriate safety measures, such as alerting the firefighters or activating an automatic system if necessary** **Sensors:** Infrared, Humidity sensor	Security and Detection
3	User Communication	**Send important information to control room technicians at a central monitoring facility and, most importantly, notify emergency services like firefighters and the police when necessary**	Communication and Alert
4	Smart Patrol	**Establish a default route trajectory for indoor navigation within a building, which includes mapping critical safety locations, such as fire risk zones and sensor placement, at specified times**	Indoor Route Planning
5	Intruder Detection	**Detection of potential intruders accessing the building without authorization along our route.** **Sensors:** Camera, microphone	Security and Detection

1.4. Release vision

Sprint number	Feature
1	**Indoor Car Navigation:** The car can move in a straight line. **Detecting and Avoiding Obstacles:** To be capable of detecting a basic obstacle and stopping the vehicle. **Instrument Reading:** Prepare the data to train the AI model to recognize manometers. **Fire detection:** Find a solution to detect a fire starting, using an infrared sensor. Develop the low-level driver and retrieve data from the sensor.
2	**Indoor Car Navigation:** maneuver the car. **Detecting and Avoiding Obstacles:** Be capable of moving again if the obstacle disappears. **Instrument Reading:** Do Image processing.
3	**Indoor Car Navigation:** Localize the car **Indoor Car Navigation & Instrument Reading:** Merge the two parts, meaning to move the car while being able to read information on manometers. **Communication:** Transfer all information (fire, manometer, intruder) to a distant station.
4 & 5	To be defined

1.5. Operational requirements

	Requirements	Identifiers	Objectives
	To move forward in an indoor environment	**[1A] Moving in a straight line**	The vehicle must be able to move in a straight line over a specified speed with a maximum error of 5%.
	To be able to take turn	**[1B] Turn**	The car can rotate with a maximum error of 5%
	To locate the car	**[1C] Location**	The car can be geolocated in a given range of 1 meter (using physical sensor place, inertial unit, indoor localisation)
	To detect fixed obstacles	**[2A] Fixed obstacles detection**	The car is able to avoid fixed obstacles within its trajectory and stop . The obstacles are detected at about **30 cm**
	To detect moving obstacles (for example employees or pedestrians)	**[2B] Moving obstacles detection**	The car is able to stop when it detects moving obstacles until they disappear from its trajectory. The obstacles are detected at about **30cm.**
	To avoid obstacles	**[2C] Avoiding obstacles**	The car can determine the size and position of an obstacle and adapt his trajectory to avoid them.
	To recognize a physical sensor	**[3A] Physical sensor detection**	The car can detect the presence of a sensor in is camera fov The car can detect a sensor around the range of **1 meter** of its perimeter
	To read a physical sensor	**[3B] Physical sensor value extraction**	The car can extract values from a physical sensor and analyze if they exceed the threshold The camera takes a scan of the reading with a precision of **0.5 bar**
	To detect start of fire as soon as possible	**[4A] Fire detection**	The car must be connect to the fire alarm system of the building The car should make a good detection 9/10 by using machine learning and computer vision technics The car should be able to alert staff immediately after detecting the first sign of fire in the building

	To follow a given and complex path to patrol	**[5A] Smart Patrol**	Conduct a round within the GEI following a predefined route. Start from one of the exits and proceed towards the entrance of the GEI with a predefined order to detect pressure gauges, come to a stop, and identify fires...
	To alert the user when an emergency is detected l	**[6A] Emergency alert**	Send a message to the user with the location of the emergency In the danger reports it is able to send the **section** of the route where it occurs without waiting the end of the patrol
	Distinguish between intruders and allowed persons	**[7A] Intruders detection**	Face recognition or pass reading (QR code) **No misidentification** between authorized and unauthorized person
	To identify suspect event	**[7B] Abnormal event detection**	Detection and report of **any abnormal** soundSmart

1.6. Reusable features

- **Project SIEC 2020**, at first sight this one looks to be the most complete and organized version. They have ROS navigation packages, ultrasonic sensors functions and a Navigation Package.
- **GProject_Benny SIEC 2022** appears to be suitable to reuse for sending GPS coordinates
- **Project Beth SIEC 2022** for Yolo (object detection)

1.7. Validation plan

Sprint 1	The car is capable of moving in a straight line from point A to point B and stopping in case of obstacles detection.
Sprint 2	The car must travel from point A to point B and locate itself along the path. And must be able to park in front of a pressure gauge to capture images without processing them.
Sprint 3	The car has a list of tasks to complete during its patrol, including checking the pressure gauge, as well as sensitive areas for fire and intrusion. It should be able to update and upgrade his position by using element along the path. No processing is done in the fire or intrusion-sensitive areas, but the car stops for 10 seconds in these areas. Regarding the pressure gauge, the car must be able to decode it and store the information.
Sprint 4	The car must not only accomplish the tasks of the previous sprints but also perform more processing. It should be able to trigger an emergency stop signal in case of high pressure or detect a flame, thus activating an alarm inside the vehicle.
Sprint 5	The car must not only accomplish the tasks of the previous sprints but also perform processing in intrusion-sensitive areas. Additionally, it should enhance its communication system with the environment, including sending real-time data to a control application or sending automatic messages to a phone number.

2. Team

Names	Skills
Raphael	Software development, Jetson Nano, Yolo
Aissatou	Machine learning and automation
Aishya	Automation, Software development C/ C++/ Java/ Python
Moad	IA,Software development TensorFlow, PyTorch, Yolo, C/C++,Python
Johann	Software development ROS2 C/C++
Eduardo	IA Software development System's control TinyML, TensorFlow, Roboflow, Yolo, Python, C/C++, Raspberry
Axel	Robotics; Low-level Software development

3. Milestones and deliverables

Date	Event Description
11/3	Deliver this document
11/6	Sprint 0 presentation (Web page and git depository)
11/14	Sprint 0 & Project plan feedback + plan for Sprint 1
11/21	Sprint 1 presentation
11/28	Sprint 1 feedback, written feedback + explanation of project (non-specialist language)
12/5	Sprint 2 presentation
12/19	Sprint 3 presentation
1/16	Sprint 4 presentation
1/30	Sprint 5 presentation (final release, final presentation, personal progress report)
1/31	Session poster

4. Project planning

4.1. First sprint planning

In Sprint 1, we are going to start defining the basic functions in an uncomplicated scenario to have a solid start.

Team/Subteam	**Tasks**	**Description**	**Difficulty**
Aishya Aissatou	Moving the car	Moving in a straight line **[1A]** **Movement with the console:** Make sure that we can move in a straight line **Autonomous movement:** Velocity control/ Position control Test in open loop/ closed loop	4/5
Moad Eduardo	Dataset manometer	Build image dataset for labeling **[3A]** Start image labeling for one class (manometre) Prepare the data to train an AI model to recognize manometers	4/5
Raphael	Detecting a basic obstacle	The car is able to avoid fixed obstacles within its trajectory and stop . The obstacles are detected at about **30 cm [2A]**	3/5
Axel Johann	Fire detection	Which sensor can we use? Study the sensor's technology and specifications. Implement a low-level driver and process the sensor data to obtain the temperature of the area. **[4A]**	3/5

4.2. Product backlog

Priority	Name	Description	Feature
1	Follow a predefined trajectory	The towing car is able to **follow a predefined trajectory**	Car Navigation in an Indoor Environment
2	Identify if an obstacle is fixed or mobile	The car **identifies whether an obstacle is fixed or mobile**	Detecting obstacles and stopping
3	Detect a small obstacle (<30cm) and stop	The vehicle can **detect a small obstacle** (<30cm, fixed or moving) and **stops as long as the obstacle is not removed**	Detecting obstacles and stopping
4	Location	The car can be **geolocated** in a given range of 1 meter (using physical sensor place, inertial unit, indoor localisation)	Car Navigation in an Indoor Environment
5	Physical sensor detection	The car can detect the presence of a sensor in is camera field of view The car can detect a sensor around the range of **1 meter** of its perimeter	Instrument Reading
6	Physical sensor value extraction	The car can extract values from a physical sensor and analyze if they exceed the threshold The camera takes a scan of the reading with a precision of **0.5 bar**	Instrument Reading
7	Emergency alert	Send a message to the user with the location of the emergency. In the danger reports it is able to send the section of the route where it occurs	User Communication

8	Periodic patrol report	Send a rapport periodically to the user The car sends a status report every minute of the trip if nothing exceptional happens, if it detects any danger it increases the notification frequency to 10 seconds.	Smart patrol
9	Transmit GPS position	The car sends it position when an alert is detected	Smart patrol
10	Smart Patrol	**Establish a default route trajectory** for indoor navigation within a building, which includes mapping critical safety locations, such as fire risk zones and sensor placement, at specified times	User Communication
11	Detect if a person is an intruder or not	The car is able to differentiate intruders and employees.	Intruder Detection
12	Abnormal event detection	Detection and report of **any abnormal** sound	Intruder Detection

4.3. Schedule control

The agile methodology provides us with a structured approach to break down our work into smaller, meaningful segments, ensuring that each part delivers value at every stage. Rather than attempting to complete and deliver everything in a single, massive effort, we will adopt an **incremental approach**, building and incorporating necessary functionalities step by step. This simplicity will be a fundamental driver for ensuring the accuracy of our work.

Our tasks have been divided into 13 distinct demonstrations (please refer to section 1.7), each of which encompasses functional and valuable user requirements. To gauge our progress and maintain adherence to our timeline, we will adhere to the agile methodology's standards. As it is rightly stated, "Working software is the primary measure of progress." Consequently, we will evaluate each new function (each story point) individually, addressing any issues that may arise during testing. Functions that align with the specified requirements will be integrated into the system, followed by a comprehensive system-wide evaluation.

To facilitate our agile project management, we will organize teams to handle various tasks efficiently.

5. Risk management

5.1. Method

Our project is built on a foundation of proactive risk management. We prioritize regular communication and thorough analysis of potential challenges. By implementing robust contingency planning and consistently monitoring our progress, we ensure adaptability and resilience in the face of uncertainties. Through ongoing collaboration and vigilant assessment, we maintain a dynamic approach to risk mitigation, safeguarding the project's success and upholding our commitment to user standards.

5.2. Risk and actions

Risks	Actions	Criticality
Team issues (miscommunication, knowledge centralization, sick-leave)	Ensure comprehensive documentation of project activities and promote regular knowledge sharing among team members. Encourage clear communication and comprehension among all team members.	High
Component shortage	Maintain a supply of spare parts to mitigate potential delays caused by component shortages.	High
Lack of components	Implement proactive measures such as early ordering to prevent delays due to insufficient components.	High
Modules incompatibility	Utilize effective version control systems like GitHub and integrate ROS to streamline module compatibility issues.	Moderate
Lack of skills	Strategically allocate project tasks based on team members' expertise & motivation and arrange necessary training sessions with tutors / teachers	Moderate
Pandemic	Establish a flexible work arrangement that allows for remote work in case of unforeseen circumstances such as a pandemic.	Low
Budget	Thoroughly estimate project costs and maintain a vigilant approach towards budget management throughout the project lifecycle.	Low
Misunderstanding of user requirements	Conduct regular and thorough user weekly feedback sessions and integrate user requirements at each project stage. Implement user-centered design principles to ensure alignment with user expectations.	Moderate