

EMERGING METHODS FOR EARLY DETECTION OF FOREST FIRES.

FINAL REPORT

TEAM ID : PNT2022TMID35102.

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INTRODUCTION:

Automated early fire detection systems have recently received a significant amount of attention due to their importance in protecting the global environment. Some emergent technologies such as ground-based, satellite-based remote sensing and distributed sensor networks systems have been used to detect forest fires in the early stages. In this study, a radio-acoustic sounding system with fine space and time resolution capabilities for continuous monitoring and early detection of forest fires is proposed. Simulations show that remote thermal mapping of a particular forest region by the proposed system could be a potential solution to the problem of early detection of forest fires.

Apart from causing tragic loss of lives and valuable natural and individual properties including thousands of

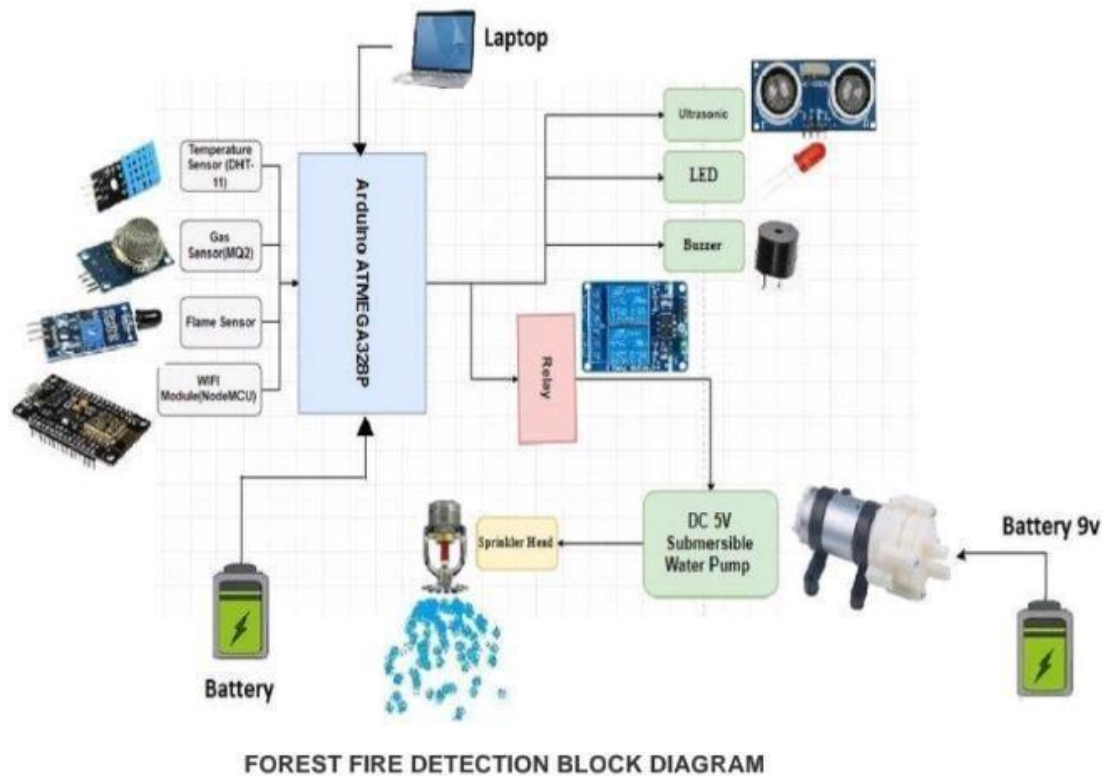


hectares of forest and hundreds of houses, forest fires are a great menace to ecologically healthy grown forests and protection of the environment. Every year, thousands of forest fires across the globe cause disasters beyond measure and description. This issue has been the research interest for many years; there are a huge amount of very well studied solutions available out there for testing or even ready for use to resolve this problem. Aim. This work will summarise all the technologies that have been used for forest fire detection with exhaustive surveys of their techniques/methods used in this application. Methods. A lot of methods and systems are available in the market and for research. Automated early fire detection due to their importance in protecting the global environment.

Objectives :

The objective is to detect the fire as fast as possible and its exact localization and early notification to the fire units is vital.

BLOCK DIAGRAM:



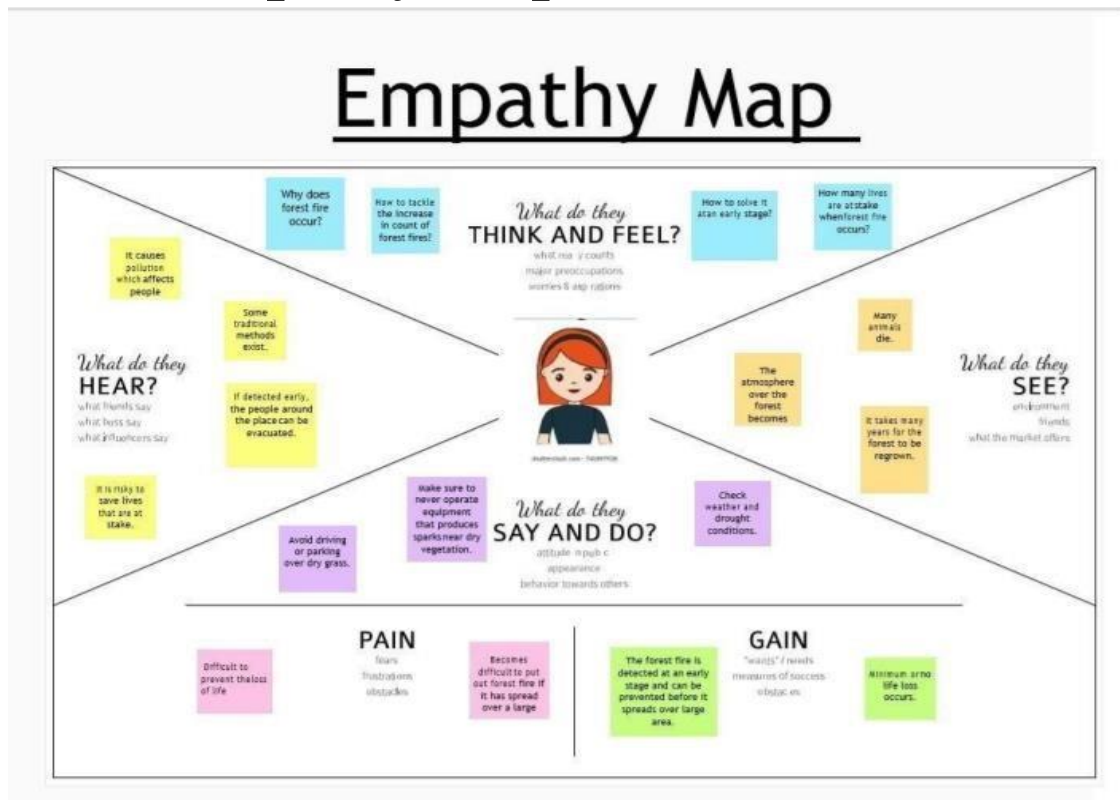
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Context: Apart from causing tragic loss of lives and valuable natural and individual p... **Methods:** A lot of methods and systems are available in the market and for research....

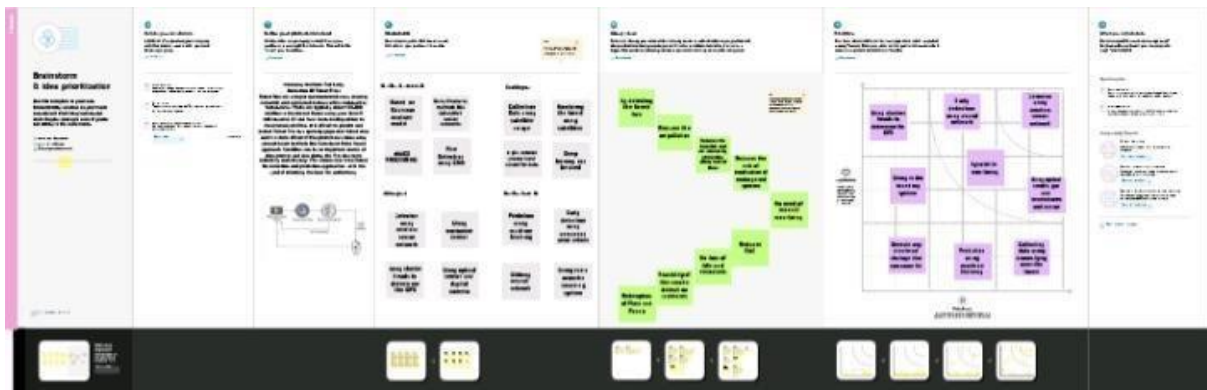
IDEATION PHASE

- Empathy Map Canvas
 - Brain storming
 - Proposed solution
 - Literature survey

○ Empathy Map Canvas :



○ Brain storming:



○ Proposed solution :

The presences of fire in video streams are indicated by semantic events. Most of the existing systems can only be used for the videos obtained from stationary cameras and videos obtained from the controlled lightening conditions. These existing automatic fire detection systems cannot be used for video streams obtained from mobile phones or any hand held devices. The KILLFIRE method is proposed to overcome these limitations. The KILLFIRE method works on two sections: i) To improve the accuracy, the Fire-like pixel detector color model is used, ii) To avoid the problem occurring in stationary videos, the new technique of motion compensation is used .

○ Literature survey :

1. **Surapong Surit, Watchara Chatwiriya** proposed a method to detect fire by smoke detection in video. This approach is based on digital image processing approach with static and dynamic characteristic analysis. The proposed method is composed of following steps, the first is to detect the area of change in the current
2. **P. Piccinini, S. Calderara, and R. Cucchiara** proposed a method based on the wavelet model and a color model of the smoke. The proposed method exploits two features: the variation of energy in wavelet model and a color model of the smoke.

3. R.Gonzalez proposed a method to detect fire based on Wavelet Transform. Stationary Wavelet Transform is used to detect Region of Interest. This method involves three steps preprocessing, SWT, histogram analysis.

4. Osman Gunay and Habiboglu proposed a system based on Covariance Descriptors, Color Models, and SVM Classifier. This system uses video data.

Project phase 1:

- **Proposal solution**
- **Problem solution fit**
- **Solution Architecture .**

† **Proposal solution.**

Projectteam shall fill the following information in proposed solution template.

S/no	Parameter	Description
1	Problem Statement (Problem to be solved)	A forest fire risk prediction algorithm, based on support vector machines, is presented. The algorithm depends on previous weather conditions in order to predict the fire hazard level of a day.
2	Idea / Solution description	Use computer vision methods for recognition and detection of smoke or fire.
3	Novelty / Uniqueness	Real time computer program detect forest fire in earliest before it spread to larger area.
4	Impact on society	Blocked roads and railway lines, electricity, mobile and land telephone lines cut, destruction of homes and industries.
5	Business Model (Revenue Model)	The proposed method was implemented using the Python programming language on a Core i3 or greater (CPU and 4GB RAM.)
6	Scalability of the Solution	Computer vision models enable land cover classification and smoke detection from satellite and ground cameras

✚ Problem solution fit phase :

Define CS, fit into CC	1. CUSTOMER SEGMENT(S) Who is your customer? i.e. working parents of 0-5 y.o. kids CS	6. CUSTOMER CONSTRAINTS What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spending power, budget, no cash, network connection, available devices. CC	5. AVAILABLE SOLUTIONS Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? i.e. pen and paper is an alternative to digital notetaking AS	Explore AS, differentiate
	The forest resources which plays a vital role in sustaining lives on the earth, therefore to preserve them from unexpected outbreak of fire and smoke. The forest management team do need this device in fire prone areas.	Climatic changes and the greenhouses gases are the reasons behind the destruction. Along with this the human factor to greedily use resources also play a vital reason for the forest fires.	Existing systems uses optical sensors for detecting forest fires. As fire is detected the sensors sends signal to the office of forest management. Among with that satellites are used to detect IR rays spotted in forest lands.	
Focus on AS, fit into BE, understand RC	2. JOBS-TO-BE-DONE / PROBLEMS Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides. J&P	9. PROBLEM ROOT CAUSE What is the real reason that this problem exists? What is the back story behind the need to do this job? i.e. customers have to do it because of the change in regulations. RC	7. BEHAVIOUR What does your customer do to address the problem and get the job done? i.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace) BE	Focus on AS, fit into BE, understand RC
	The main problem that exists is weather and climate by releasing large number of carbon dioxide, carbon monoxide and fine particulate matter into the atmosphere.	The reasons possible are: 1. Due to natural causes- Lightning 2. Man-made causes- Naked flame, cigarette, electric spark Thus, continuous care and monitoring is needed to preserve natural resources to save lives.	When fire is detected the system which is implemented to monitor the forests sets the alarm to ring, that is it gives the signal through which fire management team and the forest committee tries to call off the fire. Thus, the aim is to recognize the fire as early as possible to prevent spread of fire which will cause further damage to control.	

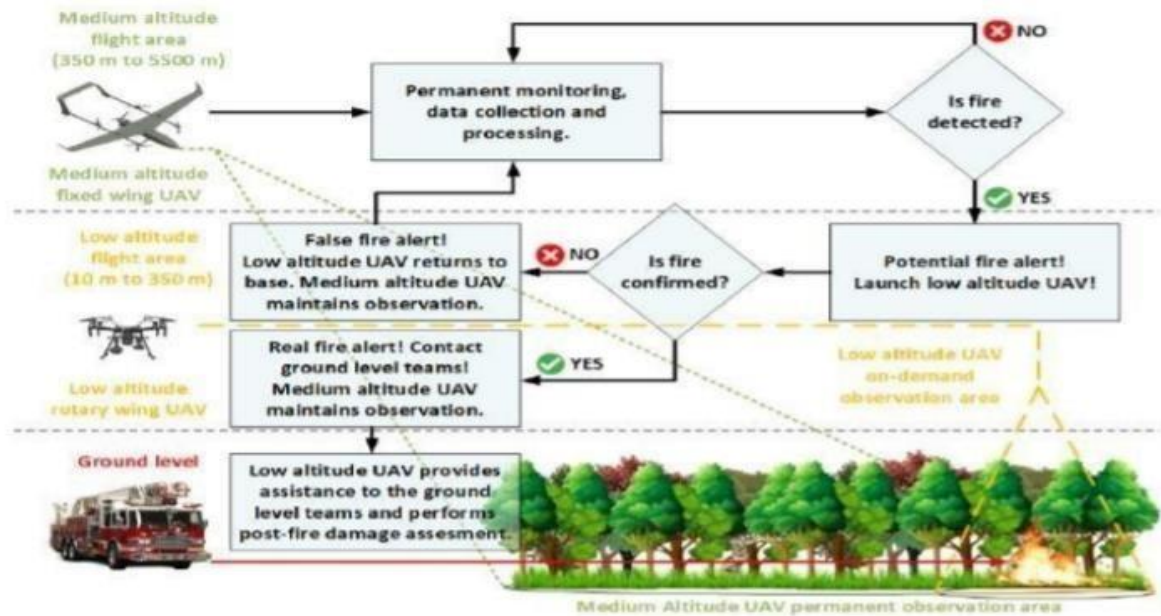
<p>3. TRIGGERS</p> <p>TR</p> <p>What triggers customers to act? (i.e. seeing their neighbor installing solar panels, reading about a more efficient solution in the news.)</p> <p>The unconscious behavior towards burned cigarette left, chances of leaving the campfire remained burnt and electric supply being disrupted</p> <hr/> <p>4. EMOTIONS: BEFORE / AFTER</p> <p>EM</p> <p>How do customers feel when they face a problem or a job and afterwards? i.e. lost, insecure → confident, in control - use it in your communication strategy & design.</p> <p>Wildfires can cause lot of stress since the factor that influence their direction and intensity are unpredictable and can change at anytime. People who have lived through wildfires can face dramatic mood swings, anxiety and mood-swings.</p>	<p>10. YOUR SOLUTION</p> <p>SL</p> <p>If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality. If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behavior.</p> <p>To minimize these losses, we have proposed a solution to detect early detection of forest fires by using CCTV camera surveillance, which can detect fire in indoor and outdoor activities. Thus instant alerts has to be sent to the forest management office so that they can take further actions to disrupt the damage caused by the fire.</p>	<p>8. CHANNELS of BEHAVIOUR</p> <p>CH</p> <p>8.1 ONLINE What kind of actions do customers take online? Extract online channels from #7.</p> <p>8.2 OFFLINE What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.</p> <p>Online Detection: Thus the chatbot or the API can connect through internet to feed you with the current status of the forest.</p> <p>Offline Detection: Thus, the forest management can send notice to the nearby residential areas or the media can bring the awareness through news, radio.</p>
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The change in temperature indicates the presence of fire or smoke in a region which can be detected by the sensors using radiation heat. As forests are in a remote location, installation and maintenance of sensors over large area is difficult. So the sensors cannot be used to deploy over large area such as forests, petrochemical plant, and saw mills etc [10] The other consequence is, the sensor would detect heat or smoke only when it reaches nearer.

Nowadays, the vision based fire detection technique is used widely to detect fires. Along with the surveillance systems the vision based fire detection technique can be incorporated at relatively low additional cost. The advantages of vision based fire detection techniques are listed here: i) the fast response to fires. ii) the location of fire is sensed using this method not just the radiation, iii) the captured images can be analyzed and it can be used for future purposes and storage, iv) it can be used for outdoor places which covers large area.

Solution Architecture

Solution Architecture Diagram:



Project phase 2 :

Customer journey

Journey Steps Which step of the experience are you describing?	Discovery Why do they even start the journey?	Registration Why would they trust us?	Onboarding and First Use How can they feel successful?	Sharing What do people typically experience as the process finishes?
Antenna What does the customer want to achieve or avoid? What is their context?	Keep tracking of climate changes. Detection of forest fire.	They can continuously monitor the forest. Collect data and image processing. Register personal records of fire range to detect.	We can track the accurate location where forest is in fire. Forest surveillance video cameras can be used to monitor the forest area so that we can prevent the people and wild fires.	This product can be only used by corporation or government to monitor forests. Prevent the area from spreading of fire.
Needs and Pains What does the customer want to achieve or avoid? The features appropriate by using the first person narrative.	To avoid the forest fire. To detect the disaster caused by forest fire. To avoid risk for animals. We want to collect the data.	Detection of fire pattern. If there happens any suspicious anomaly, with the help of this system people can get the information earlier and it also alert the forest fire department.	Corporation / Government / Forest fire department have to monitor the system regularly. Set the limits of sensor range to detect disaster.	If they have more contacts, they can share the experience to them. It is a wireless device, so it is compatible. It will also detect volcanic eruption.
Touchpoint What part of the experience do they interact with?	They can interact with the forest fire department.	System	Video, Demos, Speakers	Social Media, Sponsorship
Customer Feeling What is the customer feeling? Tip: Use the emoji app to express more emotions.	😞	😞	😞	😊
Opportunities What could we improve or introduce?	Fire removes low growing underbrush. Cleans the forest floor of debris.	Opens it up to sunlight. Nourishes the soil.	Fire frequencies determine the over storey of coniferous composition. Besides developing a natural space among the stands.	It plays a role in recycling nutrients from the ground layer vegetation and litter to the over storey trees. Thereby counteracting the infertile substrates and arrested decay.
Process Ownership Who is in the lead on this?	CORPORATION / GOVERNMENT	GOVERNMENT	FOREST FIRE DEPARTMENT	GOVERNMENT

Functional Requirements:

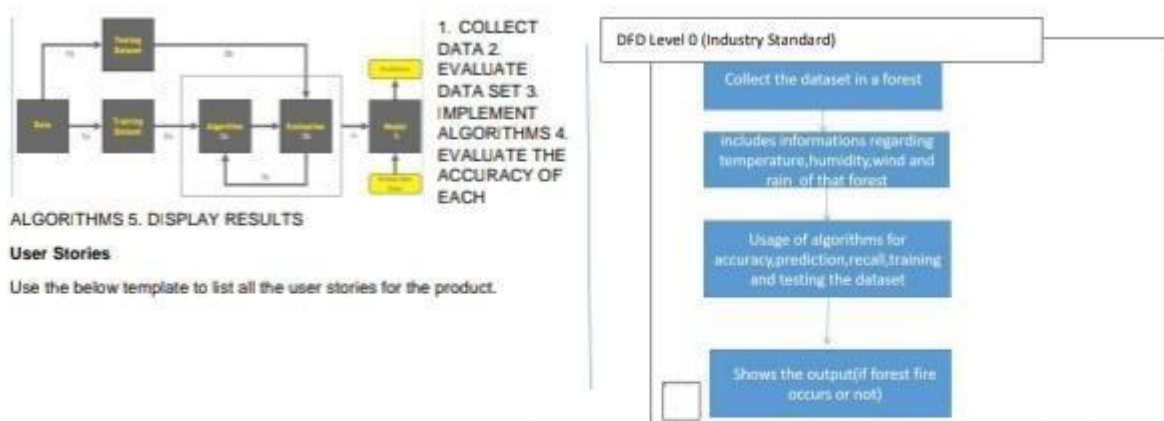
FR No.	Functional Requirement (Epic)	Sub Requirement (Story /Sub-Task)
FR-1	User Registration	Registration through Gmail
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	User Login	Login using credentials
FR-4	User Search	Search for Info on forest fire occurrence
FR-5	User Profile	User shall be given a live feed of the forest
FR-6	User Application	User is alerted if there is a forest fire occurrence in their surroundings

✚ Non-functional Requirements

Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	Alerts according to the user location
NFR-2	Security	Instant live feed with alert of the situation
NFR-3	Reliability	The prediction of the forest fire is 87% accurate
NFR-4	Performance	The feed and the alert message an immediate action without a lag
NFR-5	Availability	The application gives alerts and live feeds 24/7
NFR-6	Scalability	Early detection and alerting users are done efficiently and in a faster means

✚ Data Flow Diagram :



User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Environmentalist	Collect the data	USN-1	As an Environmentalist, it is necessary to collect the data of the forest which includes temperature, humidity, wind and rain of the forest	It is necessary to collect the right data else the prediction may become wrong	High	Sprint-1
		USN-2	Identify algorithms that can be used for prediction	To collect the algorithm to identify the accuracy level of each algorithms	Medium	Sprint-2
		USN-3	Identify the accuracy of each algorithms	Accuracy of each algorithm-calculated so that it is easy to obtain the most accurate output	High	Sprint-2
		USN-4	Evaluate the Dataset	Data is evaluated before processing	Medium	Sprint-1
		USN-5	Identify accuracy, precision, recall of each algorithms	These values are important for obtaining the right output	High	Sprint-3
		USN-6	Outputs from each algorithm are obtained	It is highly used to predict the effect and to take precautionary measures.	High	Sprint-4

✦ Technology Architecture:

Table 1 – components and technology

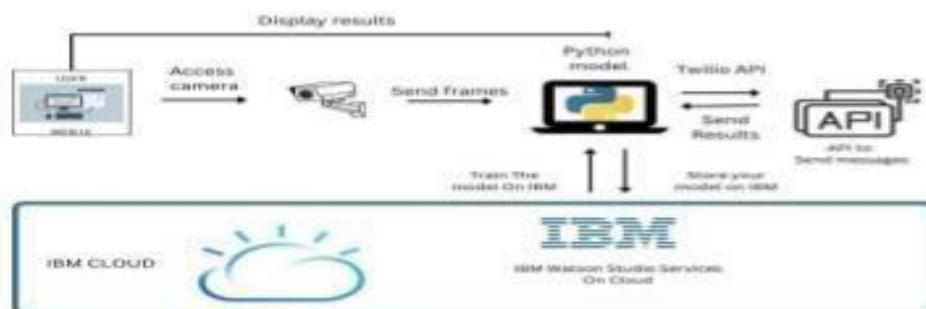


Table 1 apparatus and components

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Python Flask framework is used	Technology of Opensource framework
2.	Security Implementations	Mandatory Access Control (MAC) and Preventative Security Control is used	e.g. SHA-256, Encryptions, IAM Controls, OWASP etc.
3.	Scalable Architecture	High scalability with 3-tier architecture	Web server – HTML ,CSS ,JavaScript Application server – Python , Anaconda Database server –IBM DB2
4.	Availability	Use of load balancing to distribute traffic across servers	IBM load balancer
5.	Performance	Enhance the performance by using IBM CDN	IBM Content Delivery Network

S.No	Component	Description	Technology
1.	User Interface	The user uses the console to access the interface	Python/HTML ,CSS , Javascript and react Js
2.	Input	Video Feed	Web Camera/Video on a site
3.	Conversion	Video inputted is converted into Frames	Frame Converter
4.	Feeding the Model	The Frames are sent to the Deep learning model	Our Model
5.	Dataset	Using Test set and train set , train the model	Data set from Cloud Storage , Database
6.	Cloud Database	The model is trained in the cloud more precise with detections more images can be added later on.	IBM Cloudant ,Python Flask.
7.	Infrastructure (Server / Cloud). API	Application Deployment on Local System / Cloud Local ,Cloud Server Configuration , Twilio API to send messages	Java/python ,React Js ,JavaScript ,HTML , CSS ,IBM Cloud , OPEN CV ,Anaconda Navigator ,Local.

Table 2 – application characteristics

Project Planning & Scheduling :

Sprint Planning Estimating & Delivery Schedule

Sprint	Functional Requirement	User Story Number
Sprint-1	Installation of Beacons	USN-1
Sprint-1	Providing Wearables	USN-1
Sprint-2	Cloud Setup	USN-2
Sprint-3	Online Monitoring via Web	USN-3
Sprint-4	Monitoring via Mobile	USN-4

User Story / Task	Story Points	Priority
First the Admin will be installing smart beacons at necessary places.	15	High
The admin will be providing everyone at the industry a wearable device.	5	Medium
The smart Beacons will connect with the cloud services. Where we can get the realtime data from the wearable.	20	High
Websites will be created and connected with the cloud services.	20	High
Mobile Application will be created and fast SMS will be used to alert abnormality to the user.	20	High

Sprint 1 to 4



USER STORIES



USER ACCEPTANCE TESTING

The list are the following of user stories

User Type	Functional Requirement	User Story Number	User Story/Task	Acceptance criteria	Priority	Release
Technician	Installation	USN-1	The technician must install the smart beacons at points to ensure the entire area of the plant is covered.	A beacon can be found in every area of the plant.	High	Sprint-1
	Data Gathering	USN-2	The beacons obtain the temperature of their respective area using sensors.	The temperature of areas within the plant is obtained.	High	Sprint-1
	Data Sync	USN-3	The beacons send their data to the cloud in the real time which is in turn sent to nearby wearable devices and the administrators dashboard.	Data is sent to the cloud successfully and synced with other devices.	High	Sprint-1
Worker	Wearable device display	USN-4	The wearable devices should display the data sent by beacons within the area.	The user can see the temperature of the area on their device.	High	Sprint-1
	Wearable device adjustments	USN-5	The user can adjust the size of the wearable device to better suit them.	The user can make adjustments to the device to make working with it more comfortable.	Low	Sprint-2
	Wearable display customization	USN-6	The user can adjust the device display to suit their needs on the device itself.	The user can modify the display of the device to increase readability.	Medium	Sprint-2
	SMS Notification	USN-7	The user is sent a notification to their phone from the wearable device through an API when the area they are in reaches dangerous temperatures.	The user is informed of potential danger via SMS as soon as it is detected by the beacons.	High	Sprint-1
Administrator	Admin Dashboard	USN-8	The beacons send the data through the cloud to a dashboard which is run by the administrator.	The data of all the beacons can be viewed by the administrator of the plant.	High	Sprint-1

Results:

Performance Metrics

Forest fires are very intense deadly destroying the homes, wildlife, timber also polluting the atmosphere with hazardous compounds of pollutants. Forest fire produces various ill effects and increases the global temperature; it has a prolonged impact on landscapes and deduces the production of oxygen as it

Advantages :

- 1 controlled burning.
- 2 fire weather forecasts and estimates of fuel and moisture, watch towers.
- 3 optical smoke detection lightning detectors which detect the coordinates of the strike.

4 infrared,

5 mobile/smart phone calls becoming increasingly common for detecting fires.

Disadvantages:

- 1** Neither easy to capture suitable animals from the environment nor equip them with sensors.
- 2** Possibility of lack of appropriate animals for special forests.
- 3** Determining climate conditions, daily temp differences, seasonal normal temp values, etc. are problematic.
- 4** Use of batteries create environmental pollution, introducing extra radiation and cadmium to the forest and animals.
- 5** Moreover, each battery needs to be changed capturing the MBS to do this is not easy.

Conclusion:

New wireless technologies and new satellite tracking systems can be adapted to increase the efficiency of the system. New sensors can be produced or existing sensors can be improved to increase robustness of the proposed system.

A number of investigations can be made regarding animal behavior in case of fire to improve system reliability.

Future Scope :

To limit the damage caused by forest fires and to control the start of fires and its spread, we have presented in this study a method

of early detection of forest fires. This method is based on three steps: Estimate the general risk level of the forest, assess and predict in several places the existence or not of fires, and alert the necessary first responders to quell the spread of the fires.

The originality of this work lies in the use of a wireless sensor and RF network distributed over the entire forest area and the deep learning methods to predict in real-time a possible origination and predicted path of the forest fire.

The current system will be implemented on a large scale with multiple sensor nodes to power and augment the data set in order to improve the accuracy and collaboration of data between multiple nodes. We plan in future work to use wind direction sensors to properly estimate and locate the start of the fire, and to collaborate with SpaceX's Star Link Program to monitor rural forest areas as well.

Appendix

Huang and K. Boyle, Antennas, "From Theory to Practice", West Sussex, United Kingdom: John Wiley & Sons Ltd, 2008. [2] AA Portable Power Corp, "Category: Li-Ion/Polymer Single Cells," 2019. [Online]. Available: <https://www.batteryspace.com/li-ionsinglecell.aspx>

Demo Link:

Demo Link: <https://youtu.be/S6JPgIz1gA0>

