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Utilization of command & control solution in smart iot networks for national monitoring and fire fighting in Iran

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Abstract

According to the fires that have threatened the country's recent life of natural areas, a system for monitoring, notification and extinguishing the fire quickly designed and built. This system is generally based on two network segments are based smart sensors and communications networks. Scenario is that in certain pilot of natural areas, fire warning information by network sensor system that is final processed by software algorithms, will be send to the local command & control center via the communication network.

Considering the extent and severity of the event, the center operator with respect to the extent and severity of fire events; will send the coordination of that point into latitude & longitude, provide instructions for forester, command vehicle & the helicopter carries the water. Fire operations center also monitor the real-time feedback and reports to the headquarter centers.

Keywords:

Fire monitoring system, internet of things, smart sensor, video monitoring camera

1- Introduction

Fire as one of the most important factors affecting forest ecosystems, destroys an average of 27.7 million hectares of forest and 1.5 million hectares of woodlands. Forest fires, regardless of their origin (natural or synthetic), can be directly affect the physical and chemical properties of soil and indirectly effect on habitat quality, plants, foliage, fauna and soil mass. In addition to the above effects, forest fire cause significant changes in other parts of the ecosystem such as wildlife, air quality and surface water flow [2], [4]. Iran is arid and semi country arid that has near the 12.4 million hectares of forests and 90 million hectares of rangeland. According to the FAO, about 94% of fires occurred in areas of natural world has anthropogenic origin that with proper management can be prevented from occurring and the damages caused by the fire but unfortunately before people realize the fire, and inform the flame arresters, fire spread most of the forest. Therefore, the use of intelligent and efficient system that can announce fire officials before it gets out of control and become a crisis is undeniable requirement. According to forests and pastures organizations need to design intelligent systems for monitoring forest fires and protect this heritage, the aim of this paper is to present proposals to implement networks consisting of sensor nodes and cameras for forest fire notification and also intelligent communication solutions for fighting forest fires on time. Due to the variety of technologies using fire monitoring system in terms of sensor and camera combination is unprecedented anywhere in the world

Each of these systems with optimal performance in fire monitoring, increases the coverage factor, the performance of the system and reduce costs in the national arena. And also, the completion of the cycle in terms of monitoring and ultimately firefighting with radio communication method similar project cannot be found, that can integrate all land and air systems in a joint operation to conserve the natural resources.

According to the orders of the great leader of the revolution to explain the resistance economy, all intelligent systems that in continue to be introduced, are designed based on intelligence and knowledge of Iranian engineers and, not only in this way can maintain the country's financial capital but also, It can be a step to offer this knowledge to the rest of the world.

Suggestion of this system in five sections, including smart monitoring system on the national arena, command and control system of the local ranger systems, vehicle command and appointed system installed on the helicopter flushing system which will present in this paper from monitoring cycle to firefighting, respectively.

2- smart monitoring system on the national arena

From long time ago, the satellite monitoring method has

been common for fire monitoring but a lower resolution observation satellites and long period of scanning the area in accordance with [2], and also impossibility of predicting fire on time, caused to use smart system solutions that is referred in this article for standard method of national monitoring at the world. This system monitor all the different parts of the forests and rangeland real-time, and in case of detection of any signs of smoke and fire, sending alarm with location of the fire to the regional command and control center.this system generally consists of the sensor system and camera system that in follow, are described.

2.1 Review of burning wood

Due to the nature of fire, it will create several gases.
When a piece of wood ($6C\_10 H\_17$) is exposed to heat, convert in a wood-burned ($C\_50 H\_10 O$) and the amount of gas (〖$10CH$〗$\_2 O$) is shown in Figure 2-2.

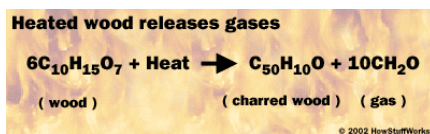$$6C_{10}H_{15}O_7 + Heat \rightarrow C_{50}H_{10}O + 10CH_2O$$

Figure 1 - Reaction of a piece of wood to heat

If this gas (〖$10CH$〗$\_2 O$) that is created by the reaction of wood and heat, subjected to the atmospheric oxygen (O_2) exhibit luminescence to gas ($H\_2 O, N\_2, CO,$〖CO〗$\_(2,)$

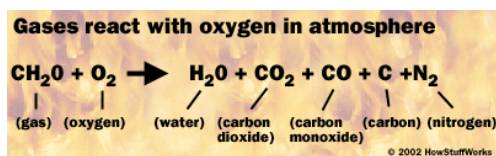$$CH_2O + O_2 \rightarrow H_2O + CO_2 + CO + C + N_2$$

Figure 2 - Burning wood with atmospheric oxygen

Figure 3 shows the four stages of a fire, such as temperature and gas to the point that are detectable by sensors, the best time to diagnosis is stage 2.
After this step, the fire can be quickly formed and within a few hours will affect a large area.
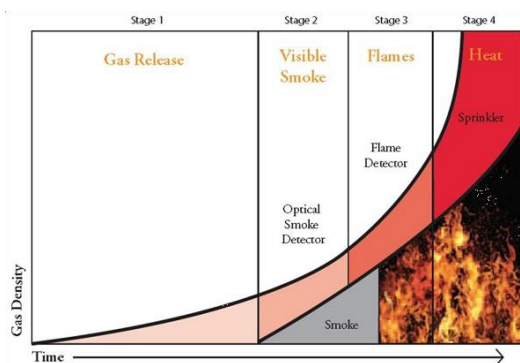

Figure 3 – Diagram of fire formation

2.2 sensor boxes network

A wireless sensor network based on intelligent sensor networks [1], consisting of a large number of sensor nodes that are widely and in an environment with self-regulation in accordance with [6] will spread and collect environmental data, processing and sending information[4]. Due to its ability to organize protocols and algorithms for sensor networks, it is not necessary that, where the sensor nodes to be predefined before.
Each sensor node in this article that is checked, has a processor on its board and instead of sending raw data, a series of initial and semi-processed data will be send to the integration device.

2.3 Introduction to sensor box

Sensor box platform used in this article, in fact, a ready platform in the field of wireless sensor networks and can support a variety of Internet of things protocols and various sensors to set things up and put them under different protocols for sensor networks and then send them in star topology to the center [10].

Figure 4 – Sensor box including temperature, humidity and carbon dioxide sensors, solar cell and telecom link

· Operating temperature - 10C ° to + 50C °
· Waterproof: IP65
· Telecom link: Lora wan (868MHz) or SIM card
· On / off button available
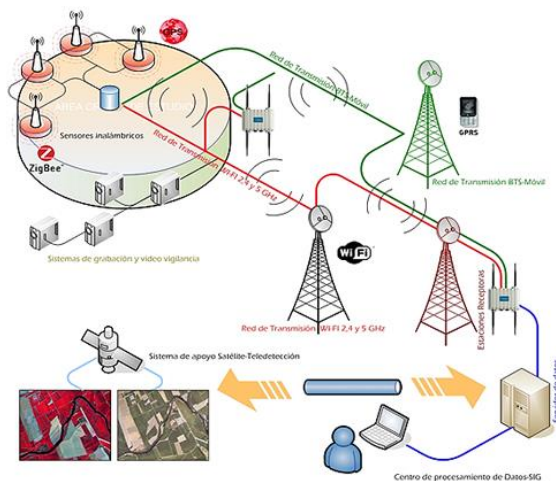. Battery: 7 days without Solar Panel (6month with solar panel)

Figure (5) – Transmitting Sensor network information and then send into the command and control monitoring and firefighting operations center

In each sensor node, the sensor data deposit to a fuzzy algorithm for fire detection. This algorithm makes that we use all the sensors capacity proportional to its influence in the region and distinguish the fire. By This work, error rate detection become low and fire can be detected with high certainty.

2.4 Transmitting smart data detected by the sensor nodes

Considering that, 80% of sensor box power needed to send monitoring fire data, so required to track the shortcut path to the integrator with the lowest sensor should be selected [8]. To achieve this, sensor nodes use a self-learning artificial intelligence algorithm called ant colony, so in addition to reducing power consumption, data rate also significantly increased in fire detection. In figure 6 understandable example for this algorithms is shown to get information in shortest path from the sensor node B to a sensor node A.
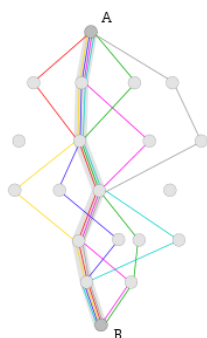

Figure (6) – Ant colony algorithm for finding the shortest path

May be due to the passage of time and the use of a commute, its battery power on that path declining and not the good path for sending and receiving. It is therefore important that algorithm always consider the energy consumption of the selected route. Figure 7 clearly illustrates this issue.
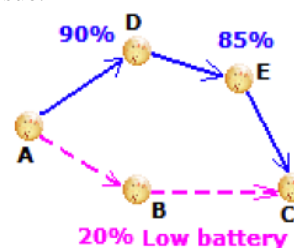

Figure 7 - Redirect transmission line considering power consumption

Sensor model presented, because of having solar cell and internal battery, even in the absence of sunlight will also be able to benefit from a period of 6 months from its internal battery power use and if using the sun light, lasts for up to 5 years.

2.5 Radio link sensor network data collection

Considering that forest fire monitoring is include vegetation and trees, Therefore, scattering due to the sensors and the possibility of damage to vegetation, wired link not recommended, and so according to performance of Lora wan radio network in Forest coverage, the link is used to send data to the command and control center.

The distance between the sensors, depends on the mass of vegetation, so due to the distribution of forest and pasture in this method, it can be computed about 70% in about 1 hectare for each sensor and about 50 meters between the sensors. Then, in a radius of about 500 meters, equivalent to 10 hectares, the integrated device is installed to get information about 10 to 20 box sensor in mesh topology and then sensor input to each of these integrators outputs that is done in a long-range connection between integrators with center, complete network of sensors centralized command and control center are carried out in accordance with experiences for 100 sensor box, with vegetation of about 70%, about 100 to 200 hectares can be covered.

2.6 Integrator

As noted above, this device; send information received from sensors under a specified protocol to the long-range link so this information be submitted to decision-making centers. It should be noted that the efficiency of this device is quite similar to other sets of sensors and sensor nodes, this device is known as a leader and try to connect through the nearest way to it [5]. In addition to this task, group of sensors similar to previous , is placed in this device that algorithm can use these sensors to calibrate sensor nodes, that this calibration will perform annually according to experience in [9], in addition fine-tuning parameters, including setting up the sending, receiving, and the sensor when it is sleeping. On the other hand, when the fire become crisis, the software used in the control center, will model the spread of fire by the climate detection control system installed on integrators sensors.

2.7 Video surveillance sites network

To speed installation operations, lower costs and higher efficiency in some cases to network sensor box, a set of video surveillance sites used for the completion of sensor network monitoring. Given the wide range of the camera view to 15 km radius able to cover 700 square kilometers and a cloud of smoke are 15 x 15 meters, these sites are used. Of course, these sites have a fundamental difference with sensor network and have better coverage of the densely areas by the sensor box to the video surveillance sites and sensors in these conditions is more responsive and it is preferred that we use these sites in areas of low-density and pastures that can cover large amount of areas. However, the use of video surveillance sites for fire detecting in day and the night has added confidence and efficiency to the system [11].

Figure (8) – Video surveillance site

These sites are used for 24 hours recognition, surveillance and tracking and can be install on fixed land or fixed platform at the proper height. Each site has a spectroscopic optical camera in day that the main task is to create the image of the target in the field and transmit data to each site to perform video signal processing, and image initial preparation, to send via high-capacity microwave radio link to command and control center.

Due to the use of heat detection facilities, sites are also able to operate at night. Because of thermal camera imaging capabilities (Thermography) these sites could be used for day and night and in the dark to detect and obtain information and understanding of the different objectives and detailed analysis of their heat.

The basis of this analysis, is on video image processing that can be achieved through a 360 degree turn of camera. Method is that every 10-degree 3-dimensional photo is taken and in the next 10 degrees shooting of this sector, previous and next photos are processed together and the information will be send by detection of smoke patterns in the video image processing software. In order to promote the process of discovering and also quicker response, multiple site video surveillance information in accordance with [12], [1] will be combined in the center as the panoramic images in output to better visible and understand
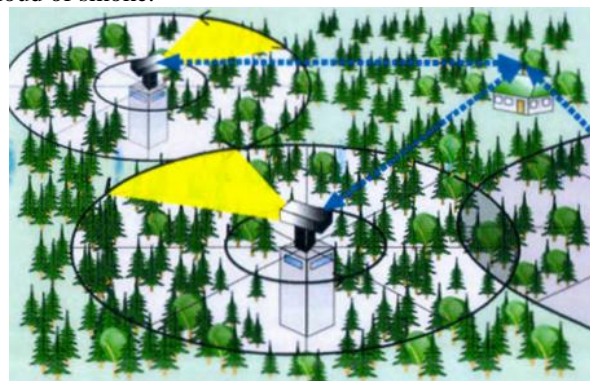
cloud of smoke.

Figure (9) – Fire detection in day and night by the spectral analysis of light at each video surveillance site.

Due to the need for a detailed breakdown of charcoal smoke and factory surroundings and from the clouds, we use software has powerful image processing algorithms to improve image quality and provide timely predictions. This software able to analyze previous history and builds on previous and new fire, the fire spread prediction model and give us best solutions and define maximum processing times to firefighting before it spread.

It should be noted that whatever is farther away from the tower installation of fire, smoke and fire of the minimum size required to detect it automatically becomes larger. Atmospheric factors affect the accuracy of detection, so that if foggy weather conditions, which is a common occurrence in the forest, the depth of camera to see become less and be more difficult to clear separation of the smoke from cloud. In addition to the existing optical sensors, fire detection, perimeter surveillance cameras using PTZ, allows you to monitor suspicious activity, including robberies and vandalism of each site is provided for command and control center.

3-   Local Command and Control Center

Need to build a central command and control center and monitoring forest events is obvious. It is assumed that the design of the Center for Buildings and infrastructure necessaries at one point in the forest that concentrator device is installed under the coverage of the telecommunications mast and it should have a room of at least 30 square meters with electricity and water , bed and other amenities along with it.

Scenario is that in a pilot area with a maximum radius of 20 km from the center, with the diagnosis and initial processing by each sensor box and video surveillance site takes place, output information send through a dedicated radio network to the command and control center of forest. then, the central control system starts to process the input data and in the event or likelihood of occurrence of fire has been reported anywhere, by getting the volume amount of smoke, the arrival time to be in the place and the spread of fire and rugged topography of the region send coordination in the format of latitude and longitude in accordance with [7], [8] for the forestry operation team.
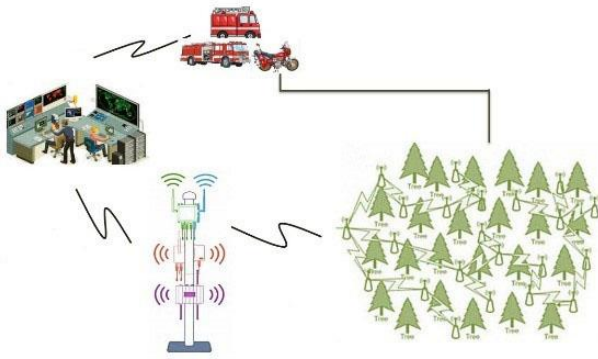
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Figure (10) – the process of sending information and operation team

3.1 Central Control System

This system has software that all information and data obtained from comprehensive forest fire detection system and meteorological information, will be integrate and showed for the operator, and allows continuous monitoring, supervision, notification of all incidents and accidents and consequently gives him faster decision making. The software also has the ability to analyze data in times of crisis, and could be due to advanced algorithms, predict the path of the fire and the fire spread dispersion model in the GIS map.

Determine the exact location of the fire and personnel, region topography, access roads, water sources, human habitation regions, determining the exact state of emergency in the fire and the procedures for applying evacuation of residents to protect the resources at risk, quick dispatch and accurate reinforcements to the firing region in digital radio communications ,tracking and recording of reinforcements, providing emergency plans to rescue forces graphically on map, Logging and recording all operations events to analyze and do next practices, online monitoring from the operations scene, inform the headquarter centers, risk assessment prior to the incident and assess the damage after the incident and submit plans for renovation after fire, determining the boundaries of the area burned in the fire and save the records for use are the other features of this system software.
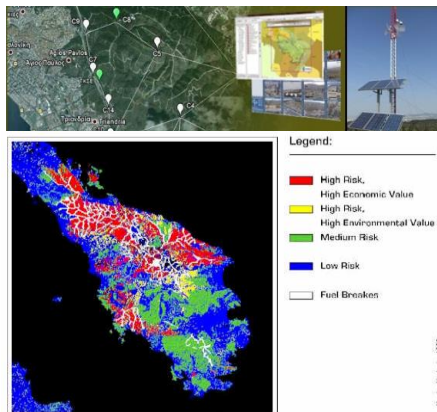

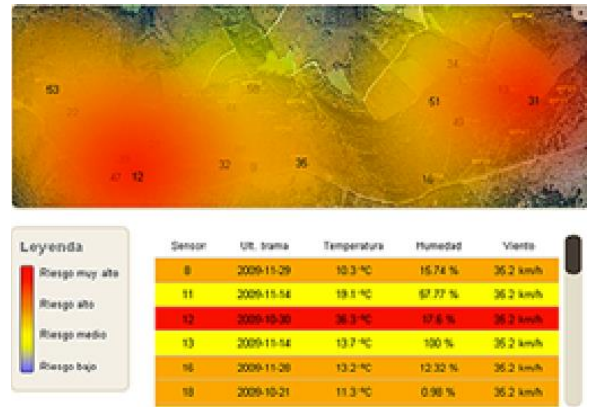Figure (11) –software of central control system

Figure (12) – View real-time status of the sensors in the center

4- The Woods ranger system

Ranger in the forest has radio DMR for voice and tablet with geographic map system to communicate to the dispatching system in center. He inspect any place suspected to smoke in the forest and the give the center the latest information gathering and firefighting's last condition. When the fire or smoke detection in the center happens, the center dispatch the woods ranger who is driving all-terrain vehicle and quickly get to the scene called ATV. The ATV can communicate with helicopter without causing overload for ranger.

Figure (13) – Motor ATV and command vehicle

5- Command vehicle system

This system includes all radio equipment and processing video images monitoring sites and sensors and, if necessary, after receiving orders from the center as a regional monitoring center as an alternative of center, will be sent to the forest area. Upon deployment of the system in the proper location, open up the mast and do regional Command within the forest. In the event that the need to monitor the surroundings from above, the drone inside the car will be sent to the desired location and then its videos and images transmitting to headquarter through satellite with the help of video conferencing system.

6- The helicopter water injection System

The mission of this helicopters begins by voice communication from the center to helicopter or helicopter airport. After delivering mission to the helicopter, and specify the location of the mission, the regional map must be loaded before flying. For example, if you have deployed

to Shiraz, then Shiraz map should load with the previous maps in helicopter's tablet. After sending the location and upon reaching a distance of 30 km from the center or command car system (in the radio coverage area) already in place, forest fire coordination information in accordance with [7], [8] or other guide icons within 30 km get listed in the tablet for better guidance and then the water injection mission start.

The route is over the fire place should be visible in the center via digital mobile radio dispatching installed on helicopter system because the center must ensure that the helicopter has been dispatched to the area has been declared or not. At the time of water injection the helicopter will be guided by the forest rangers to be directed to the desired location of the water supply in the forest and the helicopter to be informed of feedback

7- Results

With the integration of the items listed in the form of integrated network we create a full cycle of monitoring and firefighting that achieves the following objectives:

· Discovery of any fire in the shortest time possible.
· Estimate the size and exact location of the fire
· The ability to check the exact location of the fire
· Ability to predict the spread of fire
· Ability to display all regions monitored in a control center
· Ability to connect to surveillance cameras
· Ability to provide alarms to digital radios and phones
. Smart mobile communications within range of fire

With systems like these, can be due to the experience gained from this project, extend it to other IT applications of the Internet of Things such as monitoring air pollution and flood estimation are fulfilled. You can also use other agricultural applications of this technology, such as smart roads and smart city is also the opportunity to spend research funding to be operational.

Acknowledgments

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