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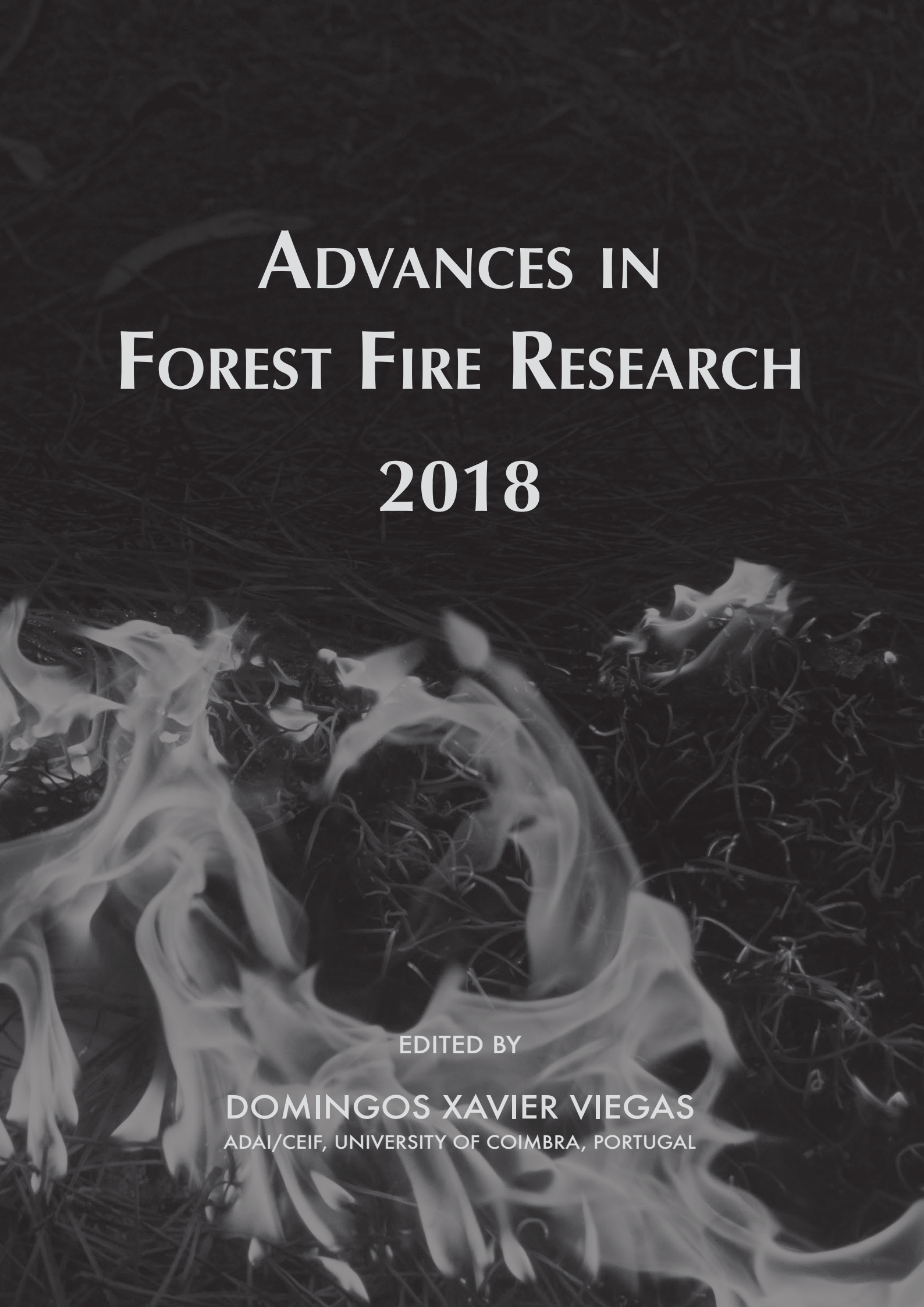

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Short contribution – Fire Management

Data mining techniques in the assessment of usability and effectiveness of forest fire video surveillance

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Abstract

Since forest fires are natural phenomenon that cannot be avoided nor their occurrence can be prevented it is of utmost importance to have a reliable fire management system at hand. Damage prevention and early fire detection are two approaches that are widely used in forest fire management today.

In the last decade, video surveillance has been recognized as useful tool for forest fire management. It helps both firefighters and forest managers in several aspects of their work, and consists of a video sensor located in the area that would otherwise be difficult to access. This sensor provides video information about the state of the surveilled forest, and can be helpful in two forest fire video surveillance phases:

- monitoring phase, that takes place before fire occurs band includes continuous monitoring of the surrounding area in search for signs of fire and smoke, and
- surveillance phase that occurs during the firefighting operative actions and that provides commanding officers with information on the severity and spread of fire.

Since there is a great demand for video surveillance for early fire detection, both in the firefighting and in the public community, this area of research is in the focus of many scientists and developers. Automatic fire detection can aid early fire response, therefore minimizing the possible fire damages while also not relying on human observers that might be suspect to inadequate experience and possible tiredness.

The work presented in this paper was motivated by the need to define quantitative measures that can help decide if a video surveillance system is effective in firefighting processes during the fire season. These measures can ultimately be used as a tool to perform cost-benefit analysis when designing and planning an integration of firefighting and forest fire management with systems for video monitoring and video surveillance.

A pilot forest fire video monitoring and surveillance system was installed in Šibenik-Knin County as the output of the HOLISTIC project at the end of 2016 fire season. In 2017 fire season the system was fully functional and used in everyday activities.

In this paper we used a variety of available data related to forest fires that took place in the area of Šibenik-Knin County in the summer of 2017. All available data was aggregated and used as the input data for the presented analysis. Several data mining techniques were used for data formatting and association. Ultimately this data was combined in a single document where the activities that were logged in the system logs were correlated with information from the operative actions reports, social media and other sources. Data mining techniques such as clustering and frequent itemset analysis were utilized for the assessment of usability of the overall video surveillance system.

The correlation of the alarms raised by the system and real operative actions in the context of media reports provide a measure of usefulness of the video surveillance system both for fire detection and for guidance during the firefighting process.

Keywords: fire monitoring, video surveillance, data mining, fire season analysis

1. HOLISTIC pilot forest fire video monitoring and surveillance system

HOLISTIC pilot forest fire video monitoring and surveillance system was installed at the end of the 2016 fire season. The system is composed of three monitoring locations - Kamenar, Dubravice and Srima, and is covering the area shown in Figure 1. Each monitoring location is equipped with two PTZ (pan-tilt-zoom) cameras mounted on a column. Each camera provides 180° cover of the surrounding area.

The software system that controles the total of 6 cameras can operate in two modes: automatic and manual. In the automatic mode the cameras move continuously, and each monitors one side of the column. The software searches for visible signs of fire and smoke. In case of suspicious phenomena, an alarm is raised. In the manual mode the camera is managed by the human operator that controls it manually via pan tilt zoom module. Manual mode is mostly used in the case of fire occurrence, as it can provide detailed visual inspection of the area to the operating centre.

Figure 1 - Area covered by HOLISTIC pilot forest fire video system

All the alarms that are raised by the system, as well as all of the actions performed in the system by an operater, are archived and can be analyzed in the post analysis of the fireseason.

2. 2017 forest fire season in Šibenik-Knin county

2017 summer fire season was especially hard in all Mediterranean countries, so Croatia and Šibenih-Knin county were no exception. The entire 2017 summer season was characterized by high and very high fire danger index, since the country went through very dry periods and received no rain for almost 3 months.

Total area burned during the fire season was mapped by firefighting commander who shared his personal records with authors for research purposes. Burned area overlayed with area protected by the monitoring system is shown in figure 2. The figure indicates that fires that occurred inside protected area are extinguished sooner and affects a smaller surface.

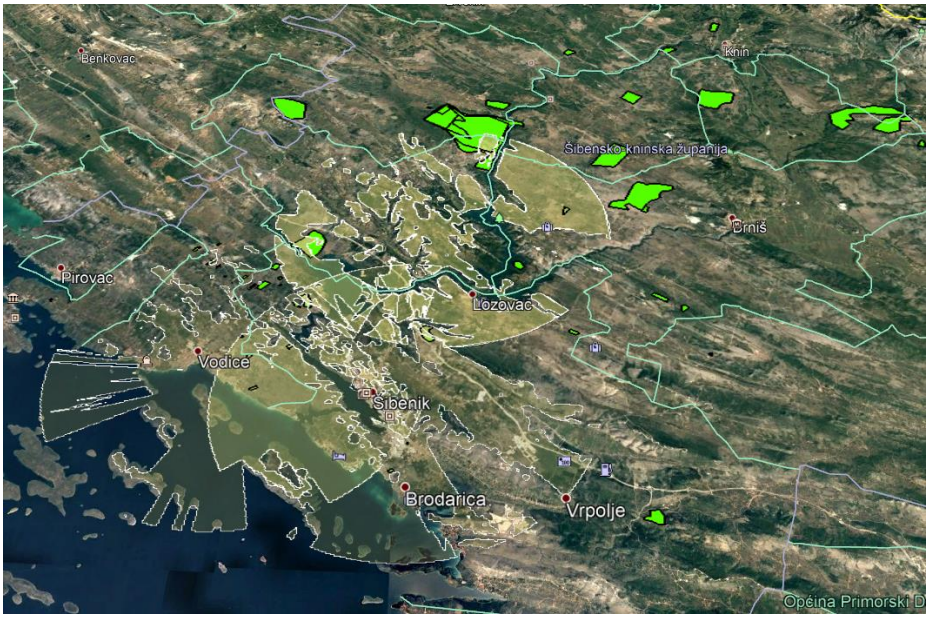

Figure 2 - Burned area during fire season overlayed with protected area of the Šibenik knin county

3. Assessment of usefulness based on data mining techniques

After the 2017 fire season, which officially starts in July and lasts until September, all alarm and activity logs were collected and used in this work. The period analyzed in this work was from the month of April, since from that period the number of fires noticeably started to rise in comparison to previous years average. This analysis included the analysis of the number of alarms per camera, and the analysis of user action logs. In the analysis of user action logs special interest was given to cases where users started to use the manual camera mode, as this was considered as a sign of the true fire alarm on that camera.

In addition, the data regarding the burned area was enhanced by personal and official data collected by the firefighters and firefighting commanders, and was aggregated into the same document on which clustering and frequent itemset analysis was performed.

4. Data Sources

Data used in assesement of usefullnes comes from various sources, such as:

1. System logs - all user interaction with the system is stored for future analysis. These logs include login information, manual/automatic mode change, parameters change and similar.
2. Burned area records - personal records kept by firefighting commander and used for official report writing and analysis. These records consists of georeferenced polygons of burned area annotated with information about date and time of start of the firefighting operative action.
3. Image archive - personal archive kept by operators for reporting and analysis. These archive consists of images stored with information about location, date and time of the fire.
4. Media and social reports - public articles on wildfires in the area analyzed. Larger fires are usually reported in news and social media.

Additionally, weather data for the season was collected and taken into account.

The process of association and analysis of all data is shown in figure 3.

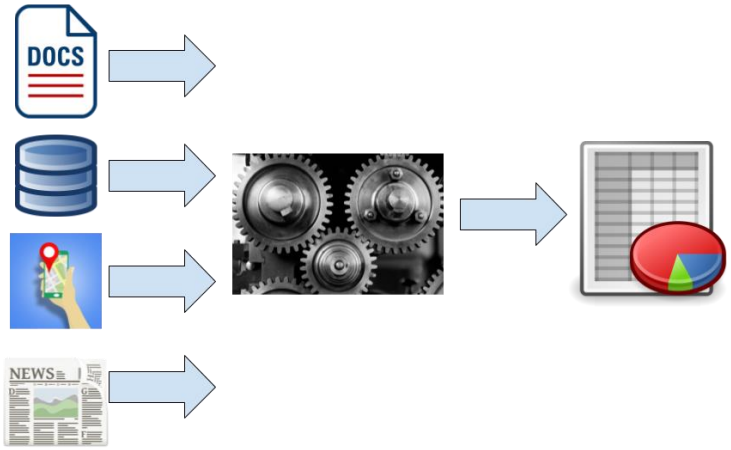

Figure 3 - Data association and processing

5. Assessment of usefulness based on data mining techniques

Data from various sources was collected, associated and preprocessed for application of data mining techniques. Two aspects of the system were taken into account while evaluating the usefulness:

- Automatic mode - analysis of valid alarms and number of false alarms
- Manual mode - analysis of system usage and helpfulness for inspection and surviellance of fires.

5.1. Analysis of automatic mode

Final associated data was used for assesement of several conclusions.

Comparison of hourly distribution of alarms and valid alarms (Figure 4) has shown that majority of false alarms happen in the morning during sunrise due to the effects of sun on camera lense. This information is taken into account when planning future development of algorithm for automatic smoke and fire detection.

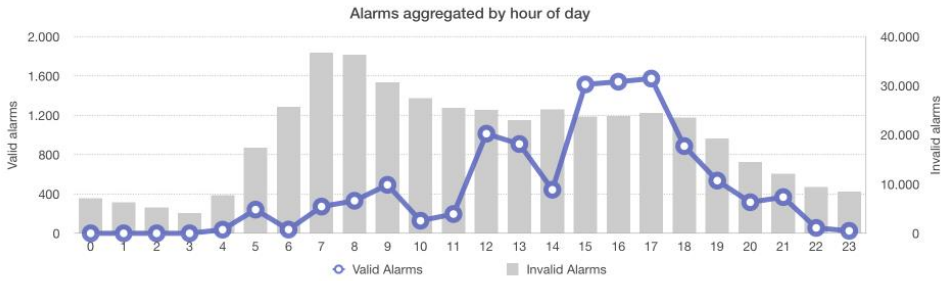

Figure 4 - Alarms aggregated by hour of day

A priori algorithm applied on collection of data shown interesting conclusions. This algorithm is used for finding frequent itemset in collection of aggregated data from various sources. We used this analysis to identify the events that often happen together. Associated events are detected using raw algorithm and later the semantics of rules for associated events are constructed.

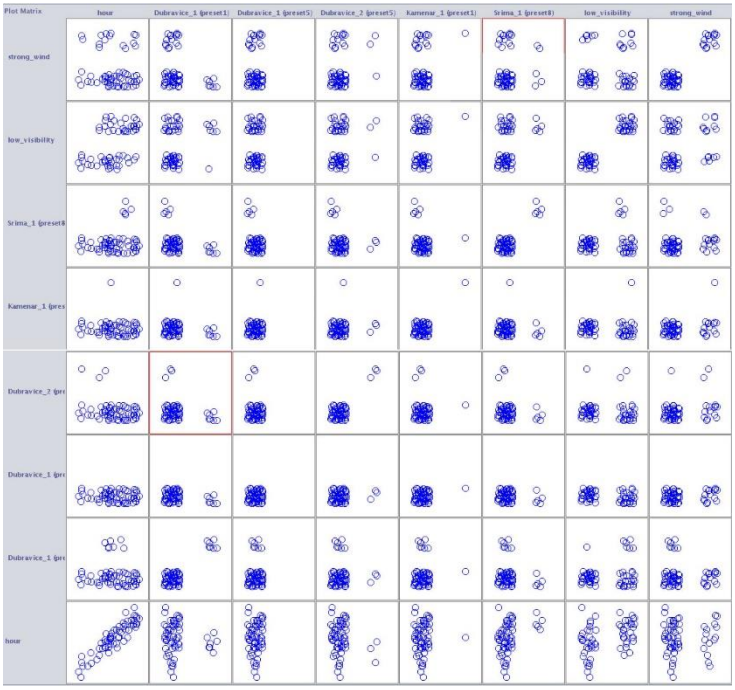

Figure 5 - Visualized results of best rules given as output from apriori analysis of valid alarms data

Figure 5 depicts the best rules calculated by apriori analysis of raised alarms after which the system was put into manual mode. The most frequent valid alarms were raised on different presets of cameras Dubravice and Srima, which in comparison with burned areas in 2017 is exactly where the fires were placed in monitored area.

Analysis was also performed on falsely raised alarms, which were very frequent in given dataset. Results of this analysis have shown that most of false alarms were raised either to bad weather conditions (low visibility or strong wind) or during the sunrise/sunset on east/west facing cameras.

Number of valid and invalid alarms aggregated by hour of day is shown on the graph above, which shows that most of invalid alarms were raised during sunrise hours.

5.2. Analysis of manual mode

Besides automatic detection of forest fires another feature of the system is manual camera control and surveillance of forest fire. To assess the usefulness of this mode we analyzed system logs and determined the length of periods when camera was used in manual mode to inspect or surveilled forest fire.

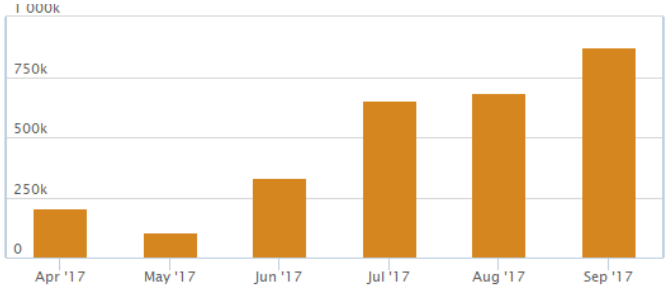

Figure 6 - Distribution of time spent in manual mode by month

During months with highest number of fires manual mode was more frequently used.

6. Results

A total of 479964 alarms was raised during the monitored period. The system was switched to manual mode 10917 times. Some of the factors that cause a lot of alarms to be raised are camera's azimuth, time of the day, visibility and wind. All the aforementioned factors were taken into account while performing data analysis.

Total resulting numbers are summed in the following table:

Number of alarms	479964
Number of manual mode swich	10917
Total time in manual mode	727 h

7. Conclusions

HOLISTIC pilot forest fire video monitoring and surveillance system still has a large amount of false positive results, mostly caused by weather conditions, lens flare or camera instability. On the other hand, it is apparent that the fire affected areas in the monitored area are much smaller than the fire affected areas outside the monitored area. Considering the analysis performed on given data, cameras placed in the fire affected areas were the ones which raised the largest count of valid alarms. Even with the large number of false alarms, this proves the system's use case, which is early forest fire detection, resulting in faster firefighting reaction.

8. Acknowledgements

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