Seminar

Institute for Plasma Research

Title : Fire Protection in Coal Mine through Image Processing

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Abstract :

In this research, integration of multiple functions of thermal image processing and a warning system for coal fire monitoring is presented. Fire explosions always take the first and foremost place in safety perspective with increasing demand for energy, coal supply and coal mining. The accidents in mines also claim huge wastage of the valuable natural resources. After the firebreak out, it is very difficult to control the spreading of fire due to presence of huge amount of extremely inflammable gases and articles in mine. Uncontrolled coal seam fires are an environmental and economic problem of international magnitude. The rate of production of green house gasses from spontaneous combustion is directly proportional to the increasing value of temperature of coal, which affects the environment and also leads to global warming. The spontaneous combustion of coal also contaminates the air in the local environment, which affects the inhabitants by harmful toxic fallouts leading to asthma or Tuberculosis. The spontaneous combustion of coal in a long duration creates another problem of cracking and subsidence of land surface which causes the collapsing of ground. This thesis is aimed to study about the minimization of such hazards specially the protection of fire in coalmine so that precautionary measurements could be taken for any possible risk. In this study, the primary and primitive focus of the investigation is strictly on underground coal fire especially the Spontaneous Combustion of coal, which is the fire of coal under the earth without sufficient air to burn. The rate of increasing of heat is slow and it grows gradually upto the ignition point of coal, which leads to firebreak out. To detect the uncertain firebreak out condition, thermal imaging technique has been considered most significant among several early warning methods to recognize spontaneous combustion of coal, e.g., temperature recordings by sensors, compaction testing of coal seam, gas tests etc. The thermal imaging approach can be used from a remote distance without any disruptions and touching the coal surface quite accurately.

Research Abstract: Fire Protection in Coal Mine through Image Processing

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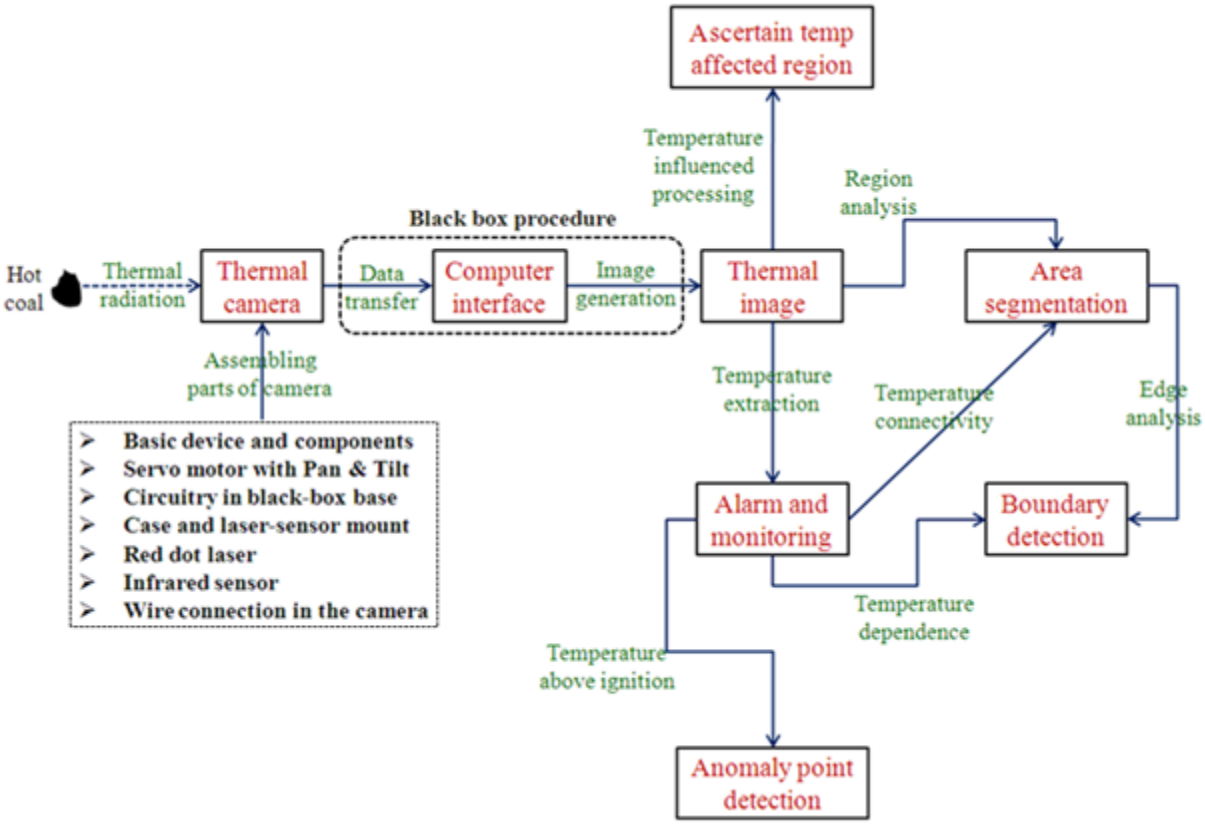
From the concluding observation of literature review, it is established that the thermal image processing is an emerging research area where area segmentation, edge detection, classification, region analysis, texture analysis, anomaly detection are still required to be investigated. For more specifically, thermal image processing based on thermal chromatics values could be an effective choice for step-by-step monitoring of firebreak out conductions. In this research, temperature of coal is considered for monitoring of firebreaks out possibilities. The thermal image processing is the most vigorous technique compared to other spontaneous combustion detection mechanisms, which are not preferable due to their limited effectiveness since the proper position of spontaneous combustion could not be located, by those technique. Thermal image processing is valuable because thermal-chromatics scale helps to indentify the respective temperature values by false color to visualize the differences. The abstract architecture of the investigated model is indicated in figure below:



The basic structure of this investigation is constructed on 4 foundation pillars e.g., framework design, core work sequence, installation of experimental setup, coding & testing. The spontaneous combustion of coal radiated as the number of infrared photon particles from coal is detected by thermal imaging camera and converted into thermographic image. The detected temperature values are distinguished by PID control technique to design different stages of frequent monitoring according to the increasing level of spontaneous combustion. Temperature value near fire ignition point of coal leads to the necessity of continuous online video monitoring system. The detection of temperature increment in camera as an event is described in event-calculus process to initiate different level of frequent monitoring. The various stages of temperature value of coal are mapped to different levels of alarms by multi-class DAGSVM process according to the potential risk of coal firebreak out. When a certain temperature value or chromatics has been detected in the camera as an occurrence of event, the multi-level DAGSVM model determines the gradual possibility of firebreak-out condition and triggers the respective alarm. The interconnectivity between detection of temperature to corresponding alarm generation is defined with the help of event-calculus process.

The basic thermal image-processing task is modeled with the help of partial differentiation technique. The visual portion in the thermal image of coal is derivate with respect to the variation of temperature to segment the affected regions separately. The edge of the affected areas is also evaluated by the mathematical foundation aspect. Segmentation of region as well as detection of boundary at different range of temperature according the various alarm levels are also evaluated by interconnectivity based thermal image processing technique. Area segmentation and edge detection at certain temperature point with two consecutive temperature levels could also be carried out by the

proposed technique. The segmentation of region and detection of edge between two certain temperature limit with upper and lower temperature range are calculated with the help of same model also. The highest thermal anomaly point or points in the image are indentified individually in squared box. The introduced techniques including frequent monitoring, alarm generation as well as thermal image processing are integrated with the help of mathematical foundation approach to establish the interconnectivity of temperature from detection in camera to resultant of images. The unification between multiple operations at a certain level of temperature is connected with interconnective operator ($\sqcap\!\bowtie$) as horizontal interoperability and integration of combined functions at different stages of temperature according to the series of alarms is linked with unification ($\bigcup$) operator as vertical interoperability in a single equation. The detection of emergency condition is also defined in-term of mathematical foundation and logic flow structure for recognizing the firebreak out condition in crisis.

The computational model of the proposed technique is designed in Unified Modeling Language (UML) diagrams especially the generation of alarm series and frequency of monitoring at different levels of temperature of spontaneous combustion. Activity and sequence diagrams of alarm generation and state with sequence diagrams of monitoring is incorporated the computational perspective of the research. The entire proposed method is illustrated in use case, package, communication as well as component diagrams to describe the connectivity of temperature between alarm generation and monitoring with thermal image processing. The programming steps in MATLAB for interconnectivity based thermal image processing technique is designed according to the sequence of propagation of temperature from camera to resulted images. The pseudo codes for alarm series and frequent monitoring is presented in this research. The components of thermal imaging camera used in the investigation are brought from abroad and assembled in the laboratory. The thermal camera is only used to capture the thermographic image and temperature data of coal. The physical temperature value of coal is collected with the help of type-k thermocouple based multimeter device. The results indicate the interrelation between thermal and physical temperature of coal, which is validated, with the help of Cramer's rule based multivariate linear regression model. The value of residual error and quintile accuracy of the proposed technique are calculated for a certain range of distance from coal to camera with the help of 3 dimensional regression analysis evaluated in Python. The descriptive sample of the alarm series and frequent monitoring process are demonstrated in programming language to confirm the features of temperature based interconnectivity method.

The measurement of distance between the location of thermal anomaly point on coal seam and the camera is required to be calculated to indentify the proper depth of the firebreak out coordinate inside the coal seam. To calculate the in-between distance, modern Laser Rangefinder device would be extremely useful in this scenario. The thermal image camera exercised in the experimental purpose is strictly used to capture the thermal image and thermographic temperature of coal. The captured thermal image of coal is generated from the manually heated coal as experimented in this research. This camera is limited to obtain still thermal image of coal instead of acquiring video thermographic data. For video capturing of thermal data of coal, higher expensive and more advanced imaging device is compulsory especially for real-time coal mining applications.