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Identification of Flash Floods using Soil Flux and CO_2: An Implementation of Neural Network with Less False Alarm Rate

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Abstract: Flash floods are very sudden and abrupt and are the major root cause of casualties and loss of infrastructure. Flash floods can be regarded as the topmost natural disasters in many countries. Usually floods are due to high precipitation, wind velocity, water wave current and melting of ice bergs. Diversified strategies have been designed and applied to identify the flash floods. Mainly dozen of sensors have been utilized to detect the flash floods like upstream level, rainfall intensity, run-off magnitude, run-off speed, color of the water, precipitation velocity, pressure, temperature, wind speed, wave current pattern and cloud to ground (CG flashes). Ultrasonic and passive infrared (PIR) sensors have also been utilized for this purpose. Sensors generate high amount of fake alerts due to the incompetent algorithms. In our research we have proposed a novel approach analysis of soil flux depicting atmospheric carbon dioxide level as the plants take smaller amount of water from the soil due to the heightened levels of carbon dioxide. Due to this newly discovered research the soil is saturated abruptly causes more floods and run-offs. In our research we have reduced the false alarms and reduced the false alarms by using scaled conjugate gradient back propagation. Simulation results showed that scaled conjugate gradient propagation performed better than the other previous methods.

Keywords: Flash flood prediction, soil flux, natural disaster, Disaster management, neural network, Carbon dioxide level

1. Introduction

Flash floods can be acknowledged as the most critical issue and major catastrophe in many countries like Philippines, Bangladesh, Malaysia, Indonesia, USA and southern France. Flash floods lead towards the high death toll and infrastructure losses [1]. Heavy and sudden rain is also common in these countries. Many sensor fusion and prediction

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algorithms have been used to resolve this issue. For the accurate and precise identification of thunderstorm, cyclone and flash floods various sensors like water upstream level indicator, precipitation velocity sensor, precipitation magnitude sensor, wind speed (anemometer), oceanic bottom pressure via acoustic link, pressure and temperature of the run-off have been utilized. Some of the researches used direct measurement method from gauges some presented the solution with combination of satellite and Radar based images in which morphological image processing was applied [1-3]. In our last previous research, we measured the integrated geomagnetic field and proved that it can be a critical tool to investigate the flash floods as geomagnetic field diminished quickly during the run-offs [2]. Many researchers have obtained high resolution X-band images from the radar to identify the flash floods and tsunamis [4]. A model was designed using Partial differential equation (PDE) for the measurement of tsunami velocity, elevation and pattern.

Many case studies and analysis have been carried out by applying Adaptive neuro fuzzy inference system (ANFIS), Kalman filtering, Fuzzy Logic controller (FLC), Particle swarm optimization (PSO), Support vector machine (SVM), Extended Kalman filtering (EKF), Fuzzy inference system (FIS), Bayesian classifier, Neural network autoregressive with exogenous input (NNARX) and Artificial Neural Network (ANN). These methods have set a bench mark to forecast the flash floods on early basis [5-8].

In this research paper we have proposed a unique solution like observations of environmental flux levels and soil flux. Results have proved that this prediction and estimation is highly accurate and precise with the reduced false alarms.

This research paper consists of five sections. Introduction has been given in the section I. The recent on-going approaches have been discussed in the Section 2. In section 3 of methodology, problem statement and proposed solution have been elaborated in detail. Section 4 explains about the result and future enhancements while Section 5 defines the conclusion.

2. Recent Methods

2.1 Flash flood prediction methods

Several approaches have been analyzed like a device named as (NISTARA) consisting of many sensors (temperature, fire, rainfall and pressure) was fabricated to forecast the flash floods. Smoke sensors also have high false alarm rate in contrast with the temperature sensors therefore a combination of both sensors can be used. Emergency Evacuation gateways will be decided on the basis of fuzzy logic depending on the various fire intensities [9]. The increased levels of rainfall could result to the harsh weather risk with outputs from wind and cyclone events. Less peak signal of Global positioning system-precipitable water vapor (GPS-PWV) can be regarded as an early indication. It was noticed that minimum value of Global positioning system-precipitable water vapor (GPS-PWV) was recorded in the sundown time within two to three days before the flash floods and the mean level of Global positioning system-precipitable water vapor (GPS-PWV) was higher between the events of flash flood [10]. The model having the least error was selected to examine in contrast with the actual results. Mean Square Error was used to calculate the error, mean square error (MSE) value was 0.2.A system was designed using supervisory control and data acquisition (SCADA) technology to avoid flash floods, in first and second model (A and B) forward back propagation (type of neural network) were applied [1]. Radar images were not accurate and precise while rain measuring gauge did not work persistently as they required maintenance and repairing on regular basis. Recurrent Neural network was applied on Garden de Mialet a mini basin of the Gardon d'Anduze in France as a case study. This watershed was 220 square kilometers and its height ranged from 147 meters to 1170 meters with 36 % ramps. Soil is light and rugged and underground contains 94 percent of mica-schists. Calculated results explained that without any previous data neural networks are able to forecast flash floods [11-12]. For identification of meteorological changes and earth changes radar can be acknowledged as an important gauge as capabilities of radar to be used in every rough environment and surroundings [13]. For the vigorous estimation of the flash floods diversified algorithms have been analyzed. Machine learning (ML), Adaptive neuro fuzzy inference system (ANFIS), support vector machine (SVM), Fuzzy inference system (FIS), Fuzzy logic (FL). ANN (Artificial neural network), NNARX (Neural network autoregressive with exogenous input), PSO (Particle Swarm Optimization) and some other model designing techniques have been applied for designing an aggressive model for the prediction and real identification of flash floods and run-offs. It has been also proved in our previous research that geomagnetic field that is emitted from the earth source reduced suddenly during flash floods [1-3]. Literature review shows that the measurement of environmental and atmospheric CO_2 levels has not been measured till yet to identify the flash floods therefore it can be considered as a novel approach in a cost-effective manner.

2.2 False Alarm reduction techniques

Piezoelectric sensor is usually known as ''vibration sensor'' or instant material. Microphone can be utilized for the sound input. They also do have high fake alerts [14]. Environmental data was observed and processed. Sensors conveyed the data to the base station (BS) where the data was saved. Transmission of all recorded data to the base station (BS) is costly; as a result distributive algorithms are needed so that they may remove out the false alarm as well. Two famous clustering procedures, k-means and fuzzy k-means have been applied. The fuzzy k-means worked same as k-means but the main discrepancy was that a sample was not fixedly designated to cluster; it was accredited with a degree. Bayesian classifier and fuzzy logic controller have been investigated as classifiers [15]. The main motive of the research was to classify the fake alarms. Invalid blocks (IA), QRS complexes and RR intervals were examined and if there was a false alarm found the procedure ended. QRS complexes were recognized using ABP (Arterial blood pressure) and PPG (photo plethysmograph). Minimum and maximum heart rate, summation and standard deviation of RRs were compared to the limits [16]. To authenticate the hypothesis SVDM and SVDD (support vector data description) results have been compared. Classification is the prime task in data processing and data analysis and in machine learning. Many approaches have been designed like decision trees, neural networks association rule [17].

Results proved that SD-CFAR with Extended Kalman filter can tack and pursue very well and better in contrast to other methods available for the underwater object tracking. It can track more target points precisely [18]. Diversified ways to minimize the false alarm in the forecasting of flash floods have been analyzed and carried out using different methods like Extended Kalman filtering, Kalman filtering, multilayer perceptron (MLP), Support vector machine (SVM), Genetic algorithm (GA), Particle swarm optimization (PSO), Improved Particle swarm optimization (ImPSO) and ant colony. In our proposed research the two sensors module have been used for the robust investigation of flash floods. CO_2 sensor has been utilized to determine the CO_2 levels in the environment as the latest research indicates that due to the increased levels of CO_2 in the atmosphere soil is more saturated and plants take less water. Due to this phenomenon the probability of flash flood becomes high. Humidity sensor has also been suggested with the combination of the CO_2 sensor. These sensors reading were observed and recorded and processed by the scaled conjugate gradient propagation to reduce the false alarms.

3. Methodology

A. Problem Identification

Usually UGS (Unattended Ground sensors) have increased amount of false alarm because of the incompetent detection algorithms [1]. Mostly thermal, fire and seismic sensors have high false alarm rate [9]. It is very complicated to segregate the actual real target (like walking and digging activity) [1-3]. Weather conditions also influence the output of sensors and transducers [5]. Smoke sensors are deployed in bathrooms. Steam in kitchen (stoves) and rooms (smoking) could easily trigger the false alarms. Up to 86% false alarms have been noticed in identification of Arrhythmias in the measuring sensors of Intensive Care Units (ICU). Sensors always introduce false alarm due to poor sensitivity and incompetent algorithms.

B. Proposed Solution

Moisture sensor will observe and rord the humidity level. Humidity level would be trigerred if it exceeds the threshold that has been set for the dense humid level means it will become High. Carbon dioxide sensor will measure the increased environmental carbon dioxide levels for the prediction of flash floods. CO_2 sensor has been utilized to determine the CO_2 levels in the environment as the latest research indicates that due to the increased levels of CO_2 in the atmosphere soil is more saturated and plants take less water. Due to this phenomenon the probability of flash flood becomes high [19].

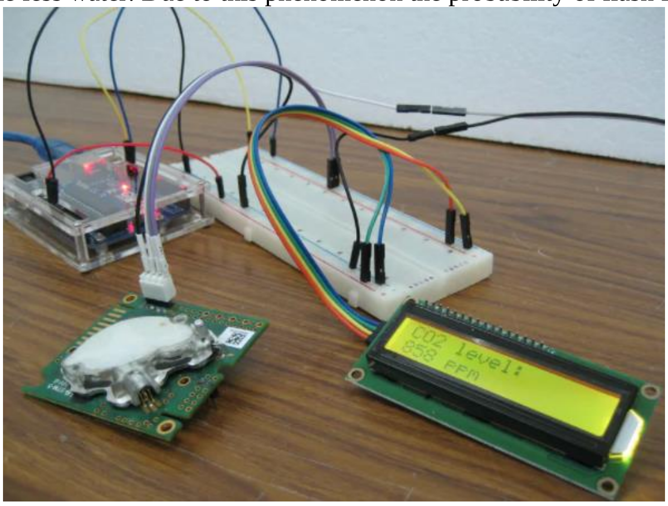

Fig. 1 - CO2 measurement using K30 sensor

Fig. 1 shows the electronic circuitry designed to observe the carbon dioxide levels in the environment. In our proposed research we have measured the environmental carbon dioxide levels and soil flux as well as the increased levels of environmental carbon dioxide saturates the soil which maximizes the probability of flash floods. K30 sensor module has been used for the identification of the carbon dioxide levels. It doesn’t have any calibration issues as it was interfaced automatically with the Arduino and Raspberry Pi. It was serially connected with the Arduino and serially interfaced with the PC.

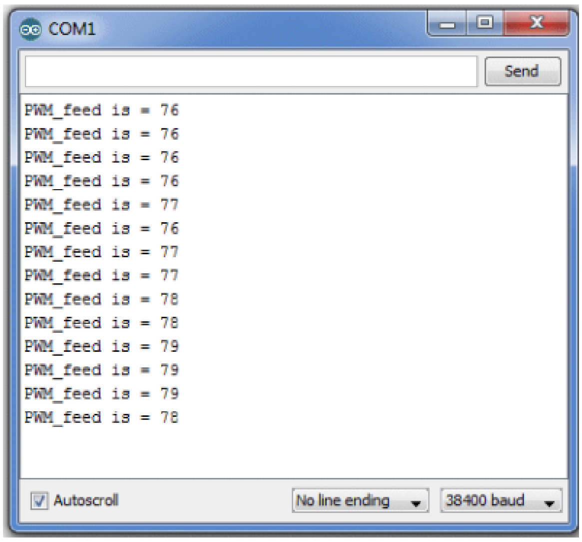

Fig. 2 – Representation of the data

Fig. 2 represents that the observed data during the run-offs. The data was received through serial interface and it can be easily saved and recorded. The data can also be received by using Bluetooth module and Wi-fi module as these modules can be interfaced with Arduino easily.

Fig. 3 - Moisture sensor

Fig. 3. Shows that moisture sensor has been deployed in parallel with the K30 sensor. It has been used as a soil humidity sensor. It was also interfaced with Arduino. The sensor detects the change in the atmospheric humidity level and soil humidity level depicting the occurrence of flash floods as it can be expected when the soil is more saturated and plants take less water.

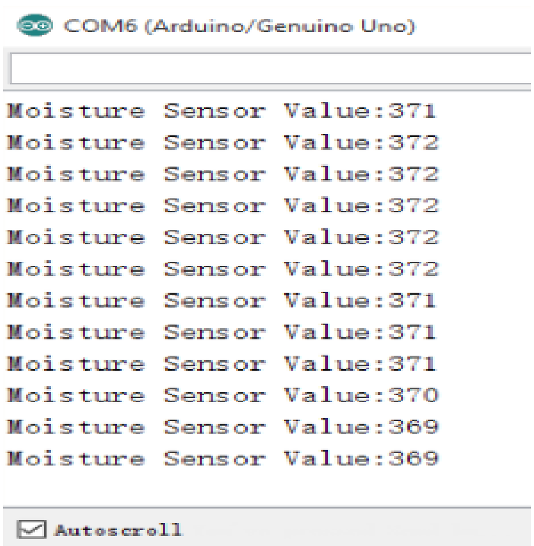

Fig. 4 - Illustration of moisture sensor reading

Fig. 4. demonstrates the experimental analysis of moisture sensor using run-offs. The data has been received through serial interface and it can be easily saved and logged. The data can also be received by using Bluetooth module and Wifi module interfaced with Arduino.

C. Scaled Conjugate Gradient Propagation

The sensors generated output would be giving output on and off data will be fed and ranges would be set. If the both sensors exceed the threshold set by the neural network the event would be triggered for sure. In our proposed research scaled conjugate gradient back propagation algorithm has been applied for the analysis of the data set of sensors. `trainscg` can train any network as long as its weight, net input, and transfer functions have derivative functions. Back propagation is used to estimate the derivatives of performance `perf` with respect to the weight and bias variables `X`. Experimental results proved that soil moisture and environmental carbon dioxide can used a major yardstick and gauge to detect the flash floods and run-offs accurately and precisely.

4. Results and Discussion

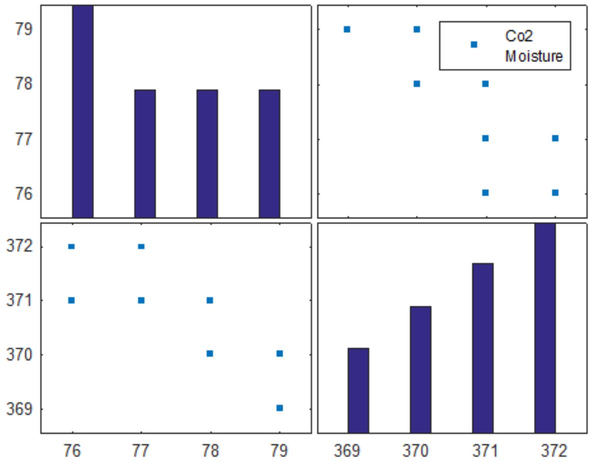

Fig. 5 - Co2 and moisture levels

Fig. 5. displays the moisture levels carbon dioxide levels that have been observed and recorded from these two transducers during flash floods. These two sensors readings have been validated and evaluated at seaside. These readings exceeding the threshold gave the output of high signal and fed to train the neural network. Both the sensors have sensed properly and scaled conjugate gradient back propagation classified the data and reduced the expected flash alarm ratio. This method can be acknowledged as cost effective solution and worked better or equal to the existing approaches available for the investigation of the flash floods correctly and precisely.

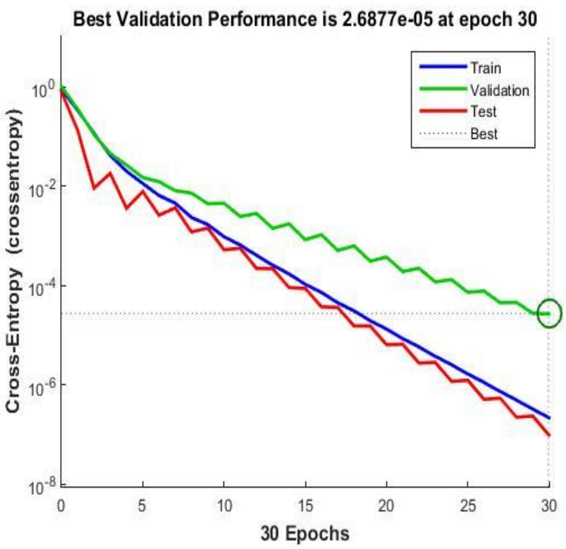

Fig. 6 - Validation performance

Fig. 6 shows validation performance simulation results. Simulations results were obtained from MATLAB by processing learning algorithm scaled conjugate gradient propagation. The graphical analysis of cross-entropy shows that training of the neurons has been done successfully. It has been tested and validated and they are close enough to each other. Best performance, best validation performance and best training performance are best_perf: 2.1838e-07, best_vperf: 2.6877e-05, best_t,perf: 9.7602e-08.

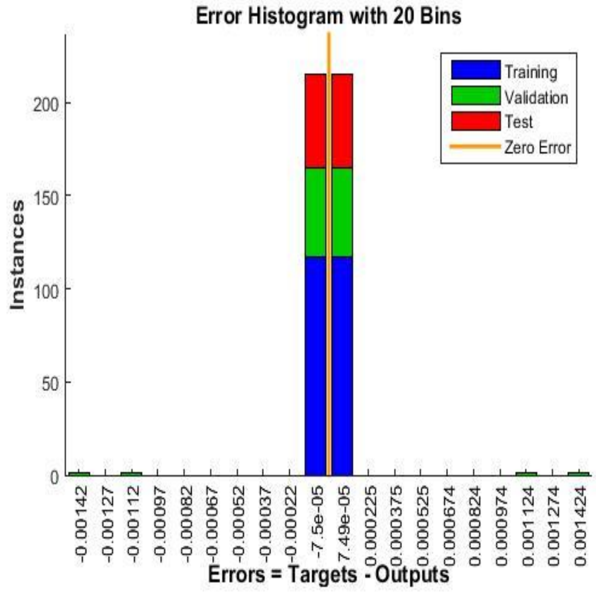

Fig. 7 - Error Histogram

Fig. 7 illustrated the error histogram that how a system responds. The error histogram is generated by the simulation which has been performed in the MATLAB. The error histogram shows the zero error. Test data set has been applied to evaluate the performance of the scaled conjugate gradient propagation.

Fig. 8 – Confusion Matrix

Confusion matrix (error matrix) can be used to evaluate the performance of the classifier algorithm. Test data set has been applied to evaluate the performance of the scaled conjugate gradient propagation. Fig. 8 shows the confusion matrix of training, validation and testing and a combined confusion matrix has also been given to evaluate the performance. Percentage gives the statistical detailed information of the classifier model. Statistical predictive analysis can be evaluated by the confusion matrix.

5. Conclusion

There are so many performance indices and measuring parameters available to identify the flash floods like in our previous research geomagnetic field during the flash floods was observed that is radiated from the centre of the earth. It was proved that geomagnetic field emitted from the earth diminished during the flash floods. In our research we have proposed a unique cost effective solution by measuring the increased carbon dioxide levels and moisture level. The high levels of both sensors trigger the flash floods that may damage the property and personal belongings. Particle swarm optimization (PSO) can be applied with the combination of multi-layer perceptron (MLP) that may create a hybrid algorithm for vigorous measurement as a future enhancement. Neural network scaled conjugate gradient back propagation was applied to train the data and for the false alarm reduction and results showed that it performed better than existing approaches in a cost-effective manner.

References

[1] Talha Khan, Zeeshan Shahid, Mansoor Alam, MS. Mazliham," Prior Investigation for Flash Floods and Hurricanes, Concise Capsulization of Hydrological Technologies and Instrumentation: A survey ", International Conference on Engineering, Technologies and Social Sciences 7-8 August 2017 (ICETSS-2017), Thailand

[2] Talha Ahmed Khan, Kushairy Kadir, Muhammad Alam, Zeeshan Shahid, MS.Mazliham, "Geomagnetic Field Measurement at Earth Surface: Flash Flood Forecasting using Tesla Meter", *Proc. of the International Conference on Engineering Technologies and Technopreneurship (IEEE-ICE2T 2017) 18-20 September 2017, Kuala Lumpur, Malaysia*

[3] B. L. Cheong, R. Kelley, R.D. Palmer, Y. Zhang, M. Yeary, and T.-Y. Yu, "PX-1000: A solid-state polarimetric X-band weather radar and time-frequency multiplexed waveform for blind range mitigation," IEEE Trans. Instrum. Meas., vol. 62, no. 11, pp.3604-3072,2013.

[4] B. L. Cheong, R. Kelley, R.D. Palmer, Y. Zhang, M. Yeary, and T.-Y. Yu, "PX-1000: A solid-state polarimetric X-band weather radar and time-frequency multiplexed waveform for blind range mitigation," IEEE Trans. Instrum. Meas., vol. 62, no. 11, pp.3604-3072,2013.

[5] S. Zhang, L. Lu, J. Yu and H. Zhou, "Short-term water level prediction using different artificial intelligent models," *2016 Fifth International Conference on Agro-Geoinformatics (Agro-Geoinformatics)*, Tianjin, 2016, pp. 1-6.doi: 10.1109/Agro-Geoinformatics.2016.7577678

[6] K. W. Chau, "Particle swarm optimization training algorithm for ANNs in stage prediction of ShingMun River, "*J. Hydrol.* , 2006.

[7] P.C. Nayak, B. Venkatesh, B. Krishna, and S. K. Jain, "Rainfall-runoff modeling using conceptual, data driven, and wavelet based computing approach," *J. Hydrol.* ,2013.

[8] M. R. M. Romlay, M. M. Rashid and S. F. Toha, "Development of Particle Swarm Optimization Based Rainfall-Runoff Prediction Model for Pahang River, Pekan," *2016 International Conference on Computer and Communication Engineering (ICCCE),* Kuala Lumpur, 2016, pp.306-310.doi: 10.1109/ICCCE.2016.72

[9] N. Bhardwaj, N. Aggarwal, N. Ahlawat and C. Rana, "Controls and intelligence behind "NISTARA-2" — A disaster management machine (DMM)," *2014 Innovative Applications of Computational Intelligence on Power, Energy and Controls with their impact on Humanity (CIPECH),* Ghaziabad, 2014, pp. 34-37.

[10] Suparta, Wayan; Rahman, Rosnani; Singh, Mandeep Singh Jit; Latif, Mohd Talib, "Investigation of Flash Flood Over the West Peninsular Malaysia by Global Positing System Network", Advanced Science Letters, Volume 21, Number 2, February 2015, pp. 153-157(5)

[11] G. Artigue, A. Johannet, V. Borrell and S. Pistre, "Flash floods forecasting without rainfalls forecasts by recurrent neural networks. Case study on the Mialet basin (Southern France)," *2011 Third World Congress on Nature and Biologically Inspired Computing*, Salamanca, 2011, pp. 303-310. doi: 10.1109/NaBIC.2011.6089612

[12] G. Artigue, A. Johannet, V. Borrell and S. Pistre, "Flash floods forecasting without rainfalls forecasts by recurrent neural networks. Case study on the Mialet basin (Southern France)," *2011 Third World Congress on Nature and Biologically Inspired Computing*, Salamanca, 2011, pp. 303-310. doi: 10.1109/NaBIC.2011.6089612

[13] M. Yeary, B. L. Cheong, J. M. Kurdzo, T. y. Yu and R. Palmer, "A brief overview of weather radar technologies and instrumentation," in *IEEE Instrumentation & Measurement Magazine*, vol. 17, no. 5, pp. 10-15, Oct. 2014.

[14] L. Muijlwijk and J. Scott, "Acoustic tamper detection sensor with very low false alarm rate," *2008 42nd Annual IEEE International Carnahan Conference on Security Technology*, Prague, 2008, pp. 94-97.

[15] M. Wälchli and T. Braun, "Event Classification and Filtering of False Alarms in Wireless Sensor Networks," *2008 IEEE International Symposium on Parallel and Distributed Processing with Applications*, Sydney, NSW, 2008, pp. 757-764.
doi: 10.1109/ISPA.2008.26

[16] F. Plesinger, P. Klimes, J. Halamek and P. Jurak, "False alarms in intensive care unit monitors: Detection of life-threatening arrhythmias using elementary algebra, descriptive statistics and fuzzy logic," *2015 Computing in Cardiology Conference (CinC)*, Nice, 2015, pp. 281-284.

[17] T. Kenaza, A. Labed, Y. Boulahia and M. Sebehi, "Adaptive SVDD-based learning for false alarm reduction in intrusion detection," *2015 12th International Joint Conference on e-Business and Telecommunications (ICETE)*, Colmar, 2015, pp. 405-412.

[18] Y. Qian, Y. Chen, X. Cao, J. Wu and J. Sun, "An underwater bearing-only multi-target tracking approach based on enhanced Kalman filter," *2016 IEEE International Conference on Electronic Information and Communication Technology (ICEICT)*, Harbin, 2016, pp. 203-207.

[19] Talha Ahmed Khan, Muhammad Alam, Kushsairy Kadir, Zeeshan Shahid and M. S. Mazliham, "A Novel Approach for the Investigation of Flash floods using Soil Flux and CO2: An Implementation of MLP with Less False *Alarm Rate", IEEE 2nd International Conference on smart sensors and applications (IEEE-ICSSA-2018), 24-26 July, Kuching, Malaysia.*