INTELLIGENT IoT ENABLE FIRE HAZARD DETECTOR DEVICE AND APPS

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ABSTRACT:

Fire hazard detection is a crucial part and one of the most critical elements in home protection. However, due to a wide variety of devices, domestic consumer failed to choose the right, reliable, and sustainable choice. Furthermore, most of the market devices did not follow the guidelines by SIRIM, since it comes from China without proper investigation on reliability. The development of the proposed method closely monitored by the Fire and Rescue Department of Malaysia. While the application and monitoring of device performance monitor by Fire Preventors Society. As to date, they are sensors in fire hazard detector; smoke, flame and gasses. We try to harmonise, those three into production rules, to avoid false alarm. Also, an addition of carbon monoxide, temperature and humidity are added to reduce the false alarm prevention mechanism to 100% of reliability. Implementation in pilot site around Kuantan and Johor Bahru show reliability, and trustworthy evaluation exceeds 90%, based on questionnaires answered by the tester for the period of the first six months.

Keywords**:** Internet of Things, Sensors, Fire Hazard, Indoor Air Measurement, Fire Hazard Prevention

INTRODUCTION

Nowadays, a lot of fire detector alarm device available to purchase due to the concern of home safety. The most noticeable detector is liquefied petroleum gas (LPG), smoke, and flame-based devices. However, this device sold separately and standalone. They are not user-centric – which the user can freely know the measurement. Most of them come from China, which suitable for four seasons countries. A tweak on the sensor is a must to make sure the accuracy of sensors is reliable. However, the consumer is not allowed to change this ready-made device.

Due to these issues, many researchers trying to enhance the current system by implementing artificial intelligence techniques (Saeed F., 2018). However, this approach seems unlikely successful due to the problem with the different sensors, and capabilities of the cheaper sensor to accurately measure the selected hazard.

Objectives

The objectives of this innovation as followed.

a. To seek an alternative way of detecting a fire hazard by studying the conventional fire hazard detector
b. To introduce artificial intelligence concept and approach in fire hazard monitoring through IoT technology
c. To implement and evaluate the software-hardware architecture prototype for IoT devices
d. To apply false alarm model with bio-inspired homeostasis negative feedback loop

e. To test the reliability of the developed device by implementing, monitoring, and investigate the performance of devices.

METHODS

The Fire Triangle or Combustion Triangle (de Paula et al., 2019), stated, three significant factors to ignite fire hazard; fuel, oxygen, and heat. Without three of them combine, no fire disaster will occur. Therefore, this innovation focusing on three sensors but with several readings, as shown in Table 1.

Table 1: Sensors in the device

Sensors	**Characteristics**	**Detection attributes**	**The Fire Triangle mapping**
MQ2	- Good sensitivity to Combustible gas in a wide range - High sensitivity to LPG, Propane and Hydrogen - Long life and low cost	Hydrogen, Liquified Petroleum Gas (LPG), Methane, Carbon Monoxide, Alcohol and Propane	Fuel and Oxygen
DHT11	- Low cost, long-term stability and fast response - strong anti-interference ability - long-distance signal transmission - digital signal output and precise calibration.	Relative humidity and temperature	Heat
YG1006	- NPN silicon phototransistor and fast response time - High photosensitivity and lead-free	Flame	-

An additional YG1006 sensor is to complement the requirement survey of the device. The survey on fire hazard prevention with 216 participants shows, the early detection of fire spark is crucial when the consumer decides on fire hazard device, 98% said it is a compulsory sensor, while 75% said need to complement with other sensors to reduce false alarm.

When conducting the testing of the sensors, MQ2 shows its capabilities to detect smoke as wells. Reduction of oxygen and humidity (from DHT11), and increment of carbon monoxide proved the smoke is existing around the device.

This innovation is combining three models of development from the field of computer science and the biology area. They are

a. Artificial intelligence through production rules technique (Roslina A.H. et al., 2018)
b. Hardware-software integration frameworks for IoT devices (Azhar A.N. et al., 2019)
c. Bio-inspired homeostasis negative feedback to prevent false alarm (Azhar A.N., 2019)

This adaptive fire hazard model is capable of catering to fast response and emergency status situation.

When the device is activated, the system will evaluate the surrounding environment. This action to prevent the four seasons incapabilities, which is not suitable for the tropical country. After the calibration, the continuous reading from surrounding begin. In this state, all sensors in `WAKE` status to sending the data to the mobile application. However, after `r` times, sensors will go into `SLEEP` condition to reduce power usage. This approach uses a mapping technique for production rules.

In occasion of fire hazard detection, all sensors will wakeup, and recent reading will be sent to production rules module to evaluate false alarm. The evaluation will take approximately three second or less to determine whether the hazard exists or not. Then it will go to homeostasis module, for second-round evaluation and perform further action.

After the emergency stages end, negative feedback module will proceed. The framework of multiple modules shown in Figure 1.

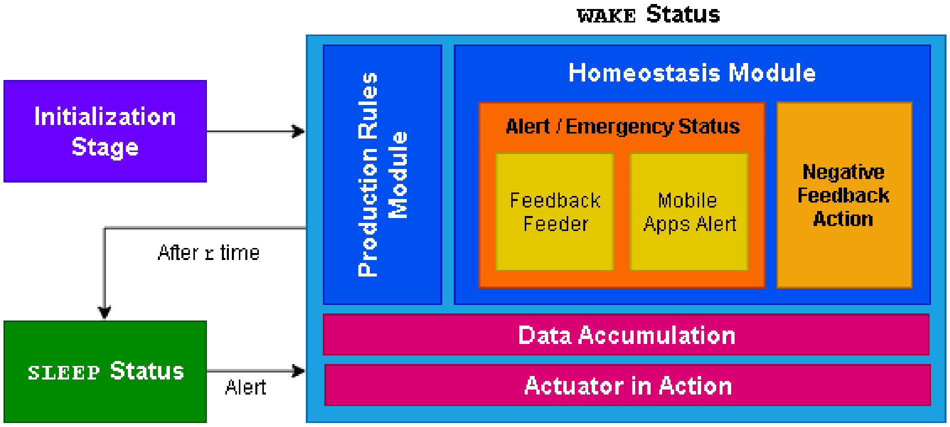

Figure 1: Bio-inspired Adaptive Hazard Model

RESULTS AND DISCUSSIONS

Two pilot testing site with 20 testers selected to use the device. The testers are already implementing either smoke, gas or/and flame detector in their residence. They are given six months to evaluate the reliability of devices. The result of the survey shown in Table 2.

Table 2: Summary of result for HeDoo Fire usage for six months

Criteria	**Kuantan Test Site**		**Johor Bahru Test Site**	
	Pre-used	After six months	Pre-used	After six months
Need changes on fire alarm systems	5%	98%	12%	100%
Easiness of usage	Conventional : 90%	Conventional : 98% Proposed : 55%	Conventional : 87%	Conventional : 88% Proposed: 99%
Reliability of device	Conventional : 85%	Conventional : 60% Proposed : 100%	Conventional : 60%	Conventional : 5% Proposed: 100%
Trusted on device	Conventional : 65%	Conventional : 5% Proposed : 100%	Conventional : 90%	Conventional : 2% Proposed: 100%

Comparing these two demographics; socio-economy and readiness are the critical factors. Kuantan site relies on the Suruhanjaya Komunikasi and Multimedia (SKMM) slow internet speed facility. While in the other hands, 100% of Johor Bahru testers use home broadband. Therefore, the easiness of the usage indirectly lower in Kuantan, due to internet connection problem.

Several issues arise based on survey analysis

a. A need for full house coverage
b. Auto disable-enable main power source
c. A short message service (SMS) due to internet connection problem
d. A website to monitoring fire hazard

CONCLUSION

As a conclusion, an innovation of fire hazard device with mobile apps in the residential area presented. The innovation tested in lab facilities and real user (residential). The electronic circuit is ready to be submitted to SIRIM and Suruhanjaya Tenaga for evaluations. For future development, they are several issues in concerns:

a. Expanded the method of data analysis to more media
b. Analysis of fire hazard assistance by implementing a fire tetrahedron approach
c. Testing the solution to the industrial consumer
d. Machine to machine and mesh network design implementation to cater more coverage area
e. Evaluating the current sensors by replacing it with a more cheaper and reliable units
f. Add actuator capabilities to the solution after evaluation took place.

ACKNOWLEDGEMENTS

This work sponsored by Universiti Malaysia Pahang Internal Research Grant (RDU170305) under the umbrella of HeDoo innovation product.

REFERENCES

Azhar, A. N. (2019). Bio-inspired negative feedback homeostasis implementation in IoT based alert systems *Unpublished manuscript*, Universiti Malaysia Pahang, Kuantan, Pahang, Malaysia.

Azhar, A. N. (2019). Indoor Air Quality Sensors Data Mapped to Students Behavior in Classroom through Production Rules Technique *Unpublished manuscript*, Universiti Malaysia Pahang, Kuantan, Pahang, Malaysia.

Azhar, A. N., Rahmah, M., Roslina, A. H., & Fauziah, Z. (2019, August). Indoor Air Quality (IAQ) Sensing Device Prototype: Software-Hardware Architecture and Performance. In *IOP Conference Series: Materials Science and Engineering* (Vol. 551, No. 1, p. 012047). IOP Publishing.

De Paula, P. R., de Arruda, F. C. F., Prado, M., & Neves, C. G. (2019). Surgical fire: principles, risk factors, and prevention. European Journal of Plastic Surgery, 42(3), 313-316.

Hamid, R. A., Mokhtar, R., Ahmad, N. A., Zainuddin, F., & Abdullah, A. (2018). i-Herbs: An Expert System for Malaysian Herbs Identification Using Production Rules Approach. *Advanced Science Letters, 24*(10), 7815-7818.

Saeed, F., Paul, A., Rehman, A., Hong, W., & Seo, H. (2018). IoT-based intelligent modelling of the smart home environment for fire prevention and safety. *Journal of Sensor and Actuator Networks*, *7*(1), 11.