DEVELOPMENT OF COLLISION AVOIDANCE APPLICATION USING INTERNET OF THINGS (IoT) TECHNOLOGY FOR VEHICLE-TO-VEHICLE (V2V) AND VEHICLE-TO-INFRASTRUCTURE (V2I) COMMUNICATION SYSTEM

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Master of Science

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Peningkatan kemalangan jalan raya telah menjadi isu yang perlu diberi perhatian di mana ia telah menyebabkan kecederaan maut dan kematian. 30% kemalangan melibatkan pelanggaran belakang manakala lebih daripada 900,000 kes dalam setahun berkaitan titik buta. Walaupun penambahbaikan keselamatan telah dinaik taraf seperti pengenalan Sistem Bantuan Pemandu (ADAS), namun angka itu masih di taraf membimbangkan. Untuk menyelesaikan isu ini, sistem Rangkaian Ad-hoc Kenderaan (VANET) dicipta untuk memastikan persekitaran yang lebih selamat untuk pemandu dan pejalan kaki. Sistem Komunikasi Kenderaan-ke-Infrastruktur (V2I) dan Kenderaan-ke-Kenderaan (V2V) adalah teknologi di bawah VANET. Disertasi ini memaparkan sistem V2V dan V2I baru bagi mengelakkan perlanggaran dengan pengembangan prototaip Unit On-Board (OBU) dan Roadside Unit (RSU) menggunakan teknologi Internet of Things (IoT). Papan Komputer Tunggal (SBC) disepadukan dengan sensor seperti GPS, LiDAR dan ultrasonik untuk OBU manakala DHT22, sensor gas CO, PM dan hujan untuk RSU. Kedua-dua OBU dan RSU dihubungkan ke internet melalui modul 4G yang diintegrasi pada SBC yang juga berfungsi sebagai server Apache-MySQL-PHP (AMP). Aplikasi Lokasi Tracker, Forward Collision Warning (FCW) dan Blind Spot Warning (BSW) disematkan ke dalam OBU yang terletak di dalam kenderaan dikenali sebagai Subject Vehicle (SV). Semua ujian melibatkan kenderaan rintangan dikenali sebagai Host Vehicle (HV) dilaksanakan di kampus Pekan Universiti Malaysia Pahang (UMP). Penemuan menunjukkan bahawa lokasi OBU adalah setepat 0.0124% untuk latitud manakala 0.0084% untuk longitud dalam masa nyata pada 60 km/j. Ketepatan GPS sedemikian membolehkan aplikasi FCW menjana amaran pada CP 80%. FCW yang dibangunkan diuji pada kelajuan SV dan HV yang berbeza dan penemuan menunjukkan bahawa amaran dijana pada jarak yang selamat dan masa yang mencukupi untuk pemandu bertindak balas. Sepanjang pengujian lapangan, TTC baru telah berjaya dirumuskan dan disahkan di mana jarak masa nyata telah dikurangkan kepada 1m dibahagikan kepada kelajuan semasa. Amaran masih dapat dijana pada peratusan perlanggaran (CP) sebanyak 80% walaupun kelewatan purata masa ketinggalan (LT) SBC direkodkan pada 1.3s. TTC dan CP yang baru dirumuskan membuktikan bahawa pemandu mempunyai cukup masa untuk bertindak balas terhadap amaran yang dihasilkan, misalnya, untuk kes HV 0 km/j dan SV 60 km/j, amaran dihasilkan pada CP 84.04% dengan TTC direkodkan adalah 2.4s hampir sejajar dengan saranan International Organizations of Standardization 2013 yang menyatakan 2.6s adalah masa terbaik untuk pemandu bertindak balas. Walaupun terdapat sedikit kelewatan dengan amaran, dengan mengambil kira jarak selamat 1m dan 1.3s LT, pemandu dapat melakukan brek selamat selepas amaran untuk memperlahankan SV sekali gus mengelakkan perlanggaran berlaku. Aplikasi BSW menunjukkan hasil yang menjanjikan dengan kelewatan hanya 1s untuk mengesan HV di titik buta pada jarak malar kelajuan 40km/j antara SV dan HV sekali gus memudahkan operasi menukar lorong. Kehadiran kenderaan HV berjaya dikesan di kawasan buta SV. Berbeza dengan OBU, RSU dikembangkan untuk memantau cuaca dan bertindak sebagai pemantau status lalu lintas. Sensor RSU berjaya mengesan jerebu, hujan, suhu dan kelembapan dengan tepat. Oleh itu, sistem ini berpotensi menghasilkan Had Kelajuan Berubah (VSL) berdasarkan keadaan persekitaran. Maklumat had laju dari RSU dapat diakses melalui OBU menggunakan internet dari teknologi 4G. Pelaksanaan teknologi IoT terbukti dapat membantu pemandu mengelak perlanggaran dan berpotensi mengurangkan kemalangan jalan raya.

ABSTRACT

Rising number of road accidents have been a common issue that needs to be given attention where most of it causes fatal injury and death. 30% of accidents are involving rear-to-end crashes meanwhile more than 900,000 cases in a year are related to rear-blind-spots. Even though safety improvements have been upgraded such as introduction of Assistance Driving Assistance System (ADAS), yet the numbers are still on its endangering path. To solve this issue, Vehicle Ad-hoc Networks (VANET) system is invented to ensure a safer environment for drivers and pedestrians. Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) Communication System is one of the technologies created under VANET. This dissertation presented the new V2V and V2I system that is applicable to avoid collisions with development of On-Board Unit (OBU) and Roadside Unit (RSU) prototype using Internet of Things (IoT) technology. Single-Board Computers (SBC) is integrated with sensors such as GPS, LiDAR and ultrasonic for OBU while DHT22, CO gas sensor, PM sensor and rain sensor for RSU. Both OBU and RSU connected to internet via 4G module integrated on the SBC which also function as Apache-MySQL-PHP (AMP) server. Location Tracker, Forward Collision Warning (FCW) and Blind Spot Warning (BSW) application is embedded into OBU located in a vehicle known as a Subject Vehicle (SV). All testing involved with obstacle vehicle known as Host Vehicle (HV) executed at Universiti Malaysia Pahang (UMP) Pekan campus. Finding shows that OBU's location is as accurate as 0.0124% in latitude while 0.0084% in longitude in real-time at 60 km/h. Such GPS accuracy allow FCW application to generate alert at CP of 80% to the driver. FCW developed is tested at different speed of SV and HV and findings shows that alert is generated at a safe distance and sufficient time for the driver to react. Throughout the field testing, the new TTC has been successfully formulated and verified where the real-time distance has been subtracted to 1 meter over current speed. Collision percentage (CP) of 80% is still generated even though the average lagging time (LT) delay of SBC is recorded at 1.3 seconds. The new formulated TTC and CP proven that the driver has ample time to respond to the generated alert, e.g., for the case of HV is at 0 km/h and SV is at 60 km/h, alert is generated at CP of 84.04% with TTC recorded at 2.4s, which is almost aligned with recommendation of International Organizations of Standardization 2013 stating 2.6s is the best time for driver to react. Even though there was a slight delay with the alerts, with consideration of 1m safe distance and 1.3s LT, driver was able to pull off a safe braking after the alert to slow down SV thus to avoid collision from happening. For BSW application, promising results by having 1 second delay in detecting blinded HV at the constant span of 40km/h speed limit between SV and HV which is an enabler to the safe lane changing operation. The presence of host vehicle (HV) or any obstacles is detected in the blinded area of SV. In contrast to OBU, RSU is developed to monitor the weather which in turn influenced the road conditions and eventually lead to the traffic status monitoring. The RSU's sensors are sensitively detected the haze, rain, temperature and humidity accurately. Therefore, this system is potentially to produce Variable Speed Limit (VSL) based on the environment conditions. Speed Limit information from the RSU can be accessed through the OBU inside the vehicles using internet from the 4G technology. Implementation of IoT technology has proven to assist the drivers in avoiding collisions thuspotential to reduce the road accidents.

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