International Journal of Engineering & Technology, 7 (4.27) (2018) 148-152

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Development of Semi-Interface Motorcycle Simulator (SiMS)

Wan Muhammad Syahmi Wan Fauzi[1*], Abdul Rahman Omar[2], Helmi Rashid[3]

[1] *Motorcycle Engineering Technology Laboratory (METAL),*
[2] *Faculty of Mechanical Engineering, Universiti Teknologi MARA,*
[3] *40450, Shah Alam, Selangor, Malaysia.*
**Corresponding author E-mail: syahmie_putraz@yahoo.com*

Abstract

Recently, studies concerning motorcycle have been an overwhelming area of research interest. As an alternative to the real world assessment, researchers have utilized motorcycle simulator as a workstation to conduct studies in the motorcycle niche area. This paper deal with the development of a new motorcycle simulator named Semi-Interface Motorcycle Simulator (SiMS). Combination of Computer Aided Design (CAD) and Finite Element Analysis (FEA) software made it possible to design and simulates the motorcycle simulator's conceptual design before being fabricated. The SiMS setup not only provides a near-to-real and immerse motorcycle riding experience on a super sport motorcycle model, but it also allows safer high speed motorcycle simulations to be conducted in a controlled environment that is portable and ergonomically easier to transport to various venues.

Keywords: *Counter-steering; Motorcycle; Semi-interface; Simulator*

1. Introduction

A great number of automobile users worldwide motivates the use of motorcycle nowadays [1]. The increased number of automobiles critically changed the traffic into a congested area. Fewer parking areas, the economic downturn and the increased of fuel costs have recently created a bunch of problems to the road users [1, 2]. Therefore, motorcycles have become a popular transportation solution to these problems.

However, motorcycles have become a global transportation safety issues where motorcyclists suffer mortality and non-fatal injury crashes [3, 4]. It is undeniable the road safety of motorcycle has been marginalized compared with the four-wheeled vehicles such as cars, vans and trucks. It is reported that motorcycle has a higher risk of death compared to the four-wheeled vehicles [5]. In Malaysia, motorcycles have contributed to road accident statistics of 100,000 motorcycles annually since 2005, yet the number is increasing each year [6]. The statistics of motorcycle road accidents in Malaysia are considerably high, hence continuous researches related to the motorcycle niche area are needed.

In the recent years, researcher have attempted to conduct studies in the motorcycle niche area. In examining these factors, as an alternative to real world assessment, researchers have utilized the motorcycle simulators or test rigs [7]. Not like other vehicle simulators that have been long established by many institutions and agencies, whether for academic, industrial or commercial purpose, the bibliography of motorcycle simulators is quite lacking [7]. There are several motorcycle simulator developed around the world such as UNIPD Motorcycle Simulator [8], IFSTTAR Motorcycle Simulator [9], NIHON Motorcycle Simulator [10] and SMARTrainer Motorcycle Simulator [11]. However, it is noticeable that most of the motorcycle simulator does not apply the law of cornering physics in motorcycle, known as counter-steering. It is one of the method of establishing the proper lean, i.e., explicitly turning the handlebars counter to the desired turn, thereby generating a centrifugal torque which leans the bike appropriately [105]. In dynamic motorcycling activity, pushing the left side of the handle bar will lean/turn the motorcycle into the left side, and vice versa. This phenomenon in known as counter-steering.

In Malaysia, group of researchers from the Motorcycle Engineering Technology Laboratory (METAL) of the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM) established a full-scale ergonomic motorcycle simulator named Postura Motergo™ as shown in Figure 1 [12]. It is a full scale ergonomic motorcycle simulator integrated with Human-Machine-Environment Interface (HMEI) that provides near-to-real riding experience within a controlled laboratory setting. The most important part is, Postura Motergo™ is integrated with a handlebar system that applies the law of counter-steering. The main purpose of the motorcycle simulator is to provide facility to conduct research in motorcycle area within the METAL laboratory. However, due to its bulky design and overweight motion system integrated the Motergo™ is permanently installed at the METAL laboratory.

Fig. 1: The Postura Motergo™

This paper deals with a development of a mobile motorcycle simulator that offers a much portable and ergonomic design setup compared to its award winning predecessor, the Postura Motergo™, a full-scale ergonomic motorcycle simulator. The new mobile motorcycle simulator named Semi-Interface Motorcycle Simulator (SiMS) provides semi human-machine-environment interface (HMEI) elements as compared to the Postura Motergo^{TM} setup, the SiMS was designed to be portable allowing it to be transported to various venues easily. The semi-interface refers to the HMEI elements that exclude the motion system and the curved screen display as provided at the Postura Motergo^{TM}. The mobility feature and more lightweight design allow users to setup the simulator for showcase events that may involve public crowds that want to test the simulator besides becoming an attraction point for visitors during exhibitions and other occasions. Other than that, company, local and international learning institutions are able to rent the SiMS facility and transport the facility outside the METAL laboratory.

2. Methodology

2.1. Conceptual Design

The primary design stage of this motorcycle simulator started with outlining several design concepts from current motorcycle simulator and Postura Motergo^{TM} as the base design. Initial sketches of the chassis concept were brainstormed to generate ideas and finally being finalized using Pugh decision matrix selection method with specific concepts criteria [13, 14]. Scores and ratings were determined and the highest total average score gained by one of the design concepts was selected as the preliminary design. Using state-of-the-art CATIA V5R20 computer aided design (CAD) software, the preliminary design was modelled for better visualization, as shown in Figure 2.

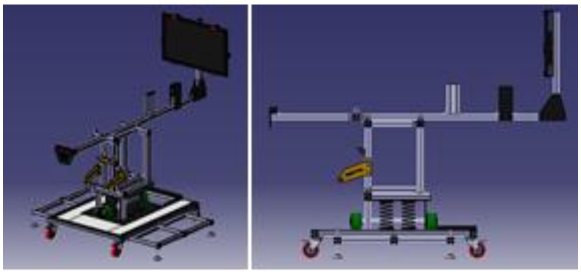

Fig. 2: Initial CAD design concept of the SiMS

The structural FEA simulations were done to predict the behaviour of the SiMS's chassis under certain loading of the motorcyclist. By this, an optimum design of the chassis can be developed with better factor of safety.

2.2. Material

The main material used in the fabrication works to build the chassis and base of the SiMS was aluminum extrusion profile CK 2702C procured from Shah Alam Engineering Hardware Sdn. Bhd., one of the hardware shop in Shah Alam, Malaysia. Other materials used range from different types of bolts and nuts, chequered plate, aftermarket motorcycle seat and fuel tank, and other few accessories as an effort to provide better replication and fidelity.

2.3. Fabrication Woks

The SiMS was fabricated in-house at the Machine Shop, Faculty of Mechanical Engineering, Universiti Teknologi MARA Malaysia to protect its IPR as shown in Figure 3. Aluminum extrusion profile CK 2702C was extensively used to build the first prototype of this motorcycle simulator due to its strength and ease of assembly and maintenance. Due to the aluminium extrusion profile that are not welded together, hence, special brackets with bolts and nuts were used to join the structures together.

Fig. 3: Fabrication works of the SiMS

3. The Prototype of Semi-Interface Motorcycle Simulator (Sims) and its Composition

Unique from other simulators, the SiMS is a motorcycle simulator that provides mobility features and applies the law of cornering in motorcycling. Figure 4 shows the prototype of the SiMS. The semi-interface ensure that the motorcycle simulator able to retain its mobility features.

Fig. 4: The prototype of SiMS

The SiMS consists of six (6) main compositions: motorcycle chassis, base platform, counter-steering handlebar system, audio-visual system, vibration element and windblast element. A PC is used to govern the SiMS. A virtual motorcycle gaming software is used and linked with a handlebar system via the USB port. The handlebar system is equipped with a simulator board (DAQ) for acquiring the sensor signal from the handlerbar inputs. Figure 5 shows the architecture of the SiMS.

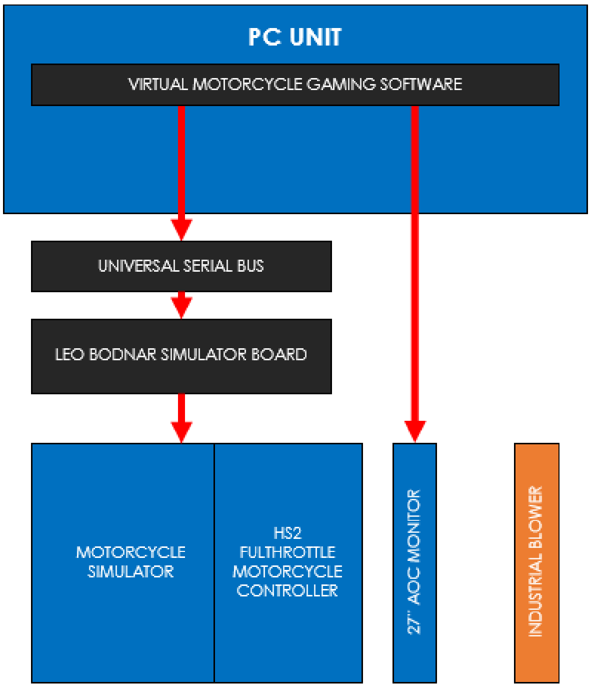

Fig. 5: Architecture of the SiMS

Unlike other motorcycle simulators that use a real motorcycle chassis and body as part of the setup, the SiMS chassis was completely designed and developed from scratch. Table 1 shows the main features of the SiMS.

Table 1: Features of the SiMS

Features	Descriptions
Semi-interface	The SiMS is integrated with semi-interface HMEI elements includes visual, noise, vibration and windblast. No motion system is integrated in order to retain its mobility.
Mobility	The SiMS is mobile to be installed anywhere, allows the motorcycle simulator to participate for showcase event and rental service for third party. The design of the base platform ensure the mobility of the SiMS.
Lightweight	The SiMS is much more lightweight due to lack of motion system.
Counter-steering	The SiMS is integrated with Hs2 Fullthrottle Motorcycle Controller, which applies the cornering physics in motorcycle known as counter-steering.
Ease of assembly and maintenance	Aluminum extrusion profile is widely used to fabricate the SiMS. Most of the joint uses bracket with bolts and nuts.
Superbike riding posture	The SiMS only provides single riding posture which is the superbike riding posture, also known as forward lean riding posture.

The following describes the composition included in the SiMS.

3.1. Motorcycle Chassis

The chassis of the motorcycle simulator was designed and modelled using state-of-the-art CATIA V5R20 software. Then the chassis was fabricated in-house, mainly using aluminum extrusion profile CK 2702C. The motorcycle chassis is integrated with standard motorcycle parts and accessories such as handlebar, steering damper, motorcycle fuel tank, clutch and brake lever, foot brake and gear shifter, seat and foot-pegs.

3.2. Base Platform

The base platform mounted the whole SiMS facility, in order to ensure its mobility and stability during operation. The SiMS's retractable base platform design uses lightweight aluminium extrusion profile CK 2702C, same as the SiMS's chassis. Additional chequered plated is used to cover the base. Four (4) specific castor wheels are attached in order to improve the mobility and manoeuvre it with minimal effort ergonomically.

3.3. Counter-Steering Handlebar System

The SiMS is integrated with a handlebar system that applies the law of counter-steering, a cornering physics in motorcycling. The handlebar system, named Hs2 Fullthrottle Motorcycle Controller was developed in collaboration with IASystems, a company based in London, United Kingdom. The Hs2, as shown in Figure 6, is connected to a PC via USB and can be linked with several motorcycles gaming software such as RIDE2015, MotoGP, GPBikes, GP 500, and Grand Theft Auto V.

Fig. 6: Hs2 Fullthrottle Motorcycle Controller

The Hs2 consists of the following inputs and output that interacts with the motorcycle game and surrounding environment setup:

i. Throttle Input (handlebar)
- Accelerates and decelerates the motorcycle.
- Controls the windblast's speed where the faster the motorcycle, the stronger the windblast and vice versa.
- Controls the noises sound level where the faster the motorcycle, the louder the surrounding noises generated from engine and air movement and vice versa.
- Controls the vibration intensity where the faster the motorcycle, the stronger it vibrates and vice versa (using the sound inputs).

ii. Left and Right Steering Input (handlebar)
- Steers the motorcycle for cornering left or right.

iii. Front Brake Input (right hand lever)
- Stops the motorcycle using front brake.

iv. Rear Brake Input (right foot brake)
- Stops the motorcycle using rear brake.

v. Gear Input (left foot gear shifter)
- Steps up or steps down the gear of the motorcycle.

vi. Clutch Input (left hand lever)
- Enables the gear to be stepped up or stepped down.

vii. Virtual Motorcycle Gaming Software Output

- As a simulation interaction medium between motorcyclist and motorcycle

Six (6) P260 Vishay Potentiometers were used to control six (6) inputs which are steering input, throttle input, front brake input, rear brake input, clutch input and gear input. These six (6) potentiometers were integrated with custom built Mechanical to Electronic (MTE) box converter, which was designed and fabricated by using 3D printing technology. The function of the MTE box is to transfer the input given by the subject, to the potentiometer, with the help of different gear ratio for each input. The potentiometers then were connected to a BU0836X Board, a special simulator board manufactured by Leobodnar Company, United Kingdom. The board consists of 32 input channels for the controller, and connected to the computer via USB cable. The computer detects the board as a game controller that enable the user to calibrate the input direct from the computer and ready to be used as a controller for any games.
For the simulation software, all motorcycle-type PC gaming software such as RIDE2015, MotoGP, GPBikes, GP 500, and Grand Theft Auto V can be used. However, for SiMS, RIDE2015 is used as the simulation software, as shown in Figure 7.

Fig. 7: RIDE2015 gaming software

3.4. Audio-Visual System Governed by A PC

A 27" AOC monitor is placed at the front part within the chassis. A custom brackets are fabricated in order to hold the monitor. For the audio, there are 2 types of audio used for SiMS which are internal audio and external audio. The internal audio provides sound for the user during operation. The internal audio is generated by a wireless headset which is implemented in a motorcycle helmet. Meanwhile, the external audio provides a surrounding sound, generated by multiple speakers place within the setup. The audio-visual system is governed by a PC which is placed on the base platform.

3.5. Vibration Element

In order to generate the vibration element within the simulator, a device named ButtKicker Gamer 2 was installed. The ButtKicker is a mechanical device that provides vibration and action from the games, via audio input. The device is widely used in most simulators, and also 4D cinemas around the world. For the motorcycle simulator, it could deliver the feel and vibration of the engine, throttling, gear shifts, bumpy road and much more. The ButtKicker Gamer 2 produces the vibration element from the audio input of the games. High amplitude of sound produced by the game will increase the vibration intensity. Figure 8 shows the ButtKicker Gamer 2 integrated into the motorcycle simulator.

Fig. 8: ButtKicker Gamer 2 integrated into the SiMS

3.6. Windblast Element

A set of industrial blower is placed in front of the motorcycle simulator to generate wind for the windblast. The wind generator is placed accordingly after careful considerations of the wind strength, range, and the rider's vision range were done. A potentiometer is connected to the blower and linked to the throttle input of the Hs2 handlebar system. This mechanism produces a similar feel of windblast during motorcycling activity. The higher the rotation of the throttle's input, the faster the motorcycle will accelerate thus, the stronger the speed of the windblast generated. The windblast's speed is monitored using a digital anemometer and placed in front of the blower.

4. Application and Experimentation Tests

The SiMS provides a motorcycling riding experience within a controlled laboratory setting, and its mobility feature and more lightweight design allow users to setup the simulator for showcase events that may involve public crowds.
The SiMS was developed based on the previous motorcycle simulator named Postura Motergo^{TM}. The previous motorcycle simulator was validated and has been used for varioud application via the surface Electromyography (sEMG). The newly developed motorcycle simulator, SiMS was validated via the semi-structured interview among a number of mechanical engineering's student from the faculty. Results obtained show that SiMS is able to simulate motions realistic enough such that experiments which involve the human factor and traffic condition, can be safely and realistically simulated. Further validation on the SiMS by using the sEMG technology will be done in the future.

5. Conclusion

Research in motorcycle area is now becoming an interesting research area to explore in an effort to help reducing motorcycle accidents that are keeping on increasing every year. Henceforth, through this paper, researchers at the Motorcycle Engineering Technology Laboratory, Faculty of Mechanical Engineering, Universiti Teknologi MARA Malaysia had made another breakthrough in motorcycle studies by introducing a new motorcycle simulator named Semi-Interface Motorcycle Simulator (SiMS). Mobility and counter-steering are the main features that differentiate SiMS with other motorcycle simulator. Although the SiMS does not come with a motion system, the special design of the left-right lean mechanism allows the motorcycle's chassis to lean left and right following the motorcyclist's body movement by adapting the natural feedback (NFB) effect. This whole SiMS setup not only provides a near-to-real and immerse motorcycle riding experience on a super sport motorcycle model, but it also allows safer high speed motorcycle simulations to be conducted in a controlled environment that is portable and ergonomically easier to transport to various venues. This project has a great potential to be pursued in more advance development such as, it can be as a training machine for our motorsport athlete like Khairul Idham Pawi and Hafizh Syahrin who competing in the Moto2.

Acknowledgement

The authors would like to acknowledge Universiti Teknologi MARA (UiTM) for providing the research funding for this research study through the Geran Penyelidikan Lestari (600-IRMI/MyRA 5/3/LESTARI (K) (002/2017)). Special thanks to the research team at the Motorcycle Engineering Technology Laboratory (METAL) especially to Muhammad Hazim bin Azman, Mohamad Syukor bin Mohamad Roze, Adzly Nazrin Sham bin Azrin Sham, Mohamad Syahir Haziq bin Tasuki, Muhammad

Iman bin Amluddin, Muhammad Ihsan bin Ridzuan, Hud bin Azahir, Nik Johar Ariff bin Nik Shamsul Bahrim and Muhammad Arif bin Sabri. Special thanks also to the technicians at the Machine Shop, Faculty of Mechanical Engineering, Universiti Teknologi MARA Malaysia and those who have directly or indirectly, contributed to this research.

References

[1] H. Arioui, L. Nehaoua, S. Hima, N. S guy, and S. Espie , Mechatronics, Design, and Modeling of a Motorcycle Riding Simulator, IEEE/ASME Transactions on Mechatronics, 13 (2010) 805-818.

[2] W. M. S. W. Fauzi, A. R. Omar, R. Jaafar, M. I. N. Ma'arof, and H. Rashid, Motorcycle Cockpit Design Classification: CODEC System, Jurnal Teknologi, 76 (2015).

[3] A. R. Omar, W. M. S. W. Fauzi , R. Jaafar, M. I. N. Ma'arof, & H. Rashid, A Review on Enhancing Human-Machine-Environment Interface for Postura Moterg^{TM}, Jurnal Teknologi, vol. 76 (2015) 21-25.

[4] L. I. C. Sàrl and Villars-sous-Yens, Global Status Report on Road Safety Switzerland, (2013).

[5] G. Murali, S. Gupta, and D. Singh, Pillion riders beware: Motorcycle fire following road side accident – An autopsy case report, Egyptian Journal of Forensic Sciences (2016).

[6] Ministry of Transport, Transport Statistics Malaysia, (2014).

[7] L. Nehaoua, H. Arioui, and S. Mammar, Review on single track vehicle and motorcycle simulators, presented at the 19th Mediterranean Conference on Control and Automation, Aquis Corfu Holiday Palace, Corfu, Greece, (2011).

[8] V. Cossalter, R. Lot, M. Massaro, and R. Sartori, Development and Testing of Assistant Rider Systems with the UNIPD Motorcycle Riding Simulator, in XIX Congresso Aimeta Associazone Italiana di Meccanica Teorica Applicata, Italy, (2009) 24.

[9] L. Nehaoua, S.Hima, H.Arioui, N.Séguy, and S.Espié, Design and modelling of a new motorcycle riding simulator, in 2007 IEEE American, American Control Conference, New York City, NY, (2007) 76-181.

[10] T. Kishida and I. Kageyama, A Study on Riding Simulator for Motorcycle, in DSC 2007 North America, Iowa City, (2007).

[11] Honda SMARTrainer. website: http://www.motorcycle.com/how-to/honda-smartrainer-86756.html (accessed 20.7.2015)

[12] W. M. S. W. Fauzi, A. R. Omar, & H. Rashid, Enhancement of Postura Motergo^{TM}: From an Ergonomic Motorcycle Test Rig to a Full-Scale Simulator, Journal of Mechanical Engineering, SI 4(4) (017) 43-59.

[13] K. Nagesh, I. Prawit, & M. Farrokh, Design through selection: a method that works. Design Studies, 6(2) (1985) 91-106.

[14] A. Thakker, J. Jarvis, M. Buggy, & A. Sahed, 3DCAD conceptual design of the next-generation impulse turbine using the Pugh decision-matrix. Materials & Design, 30(7) (2009) 2676-2684.