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FRAMEWORK OF AUGMENTED REALITY APPROACH TOWARDS ERGONOMIC ASSESSMENT OF DRIVER VEHICLE PACKAGE DESIGN

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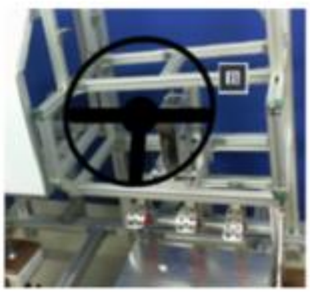
Graphical abstract



Abstract

Human factor studies such as ergonomic evaluation become increasingly important in the engineering, automotive, designing and support of new advance products. Creating in-car gadgets that can be worked inside appropriate safety bound is an ergonomic issue. Several tools and methods have been developed for ergonomic evaluation. However, there are several factors that influence the difficulty of such evaluations, such as the subjectivity of comfort, high cost of mock-up systems and computerized tools, and the disadvantage of reconfiguring adjustments. The proposed system allows the user or engineer to obtain the three-dimensional visual model with the aid of additional equipment that includes a Augmented Reality head mounted display (HMD) to reduce the components of physical prototype. The user or engineer is able to determine the position of interior components to determine the most comfortable ergonomic reaching zone.

Keywords: Car ergonomic design; augmented reality; development

Abstrak

Faktor kajian manusia seperti penilaian ergonomik menjadi semakin penting dalam kejuruteraan, automotif, reka bentuk dan sokongan produk terlebih dahulu baru. Mencipta alat dalam kereta yang boleh bekerja dalam keselamatan yang sesuai terikat adalah isu ergonomik. Beberapa alat dan kaedah telah dibangunkan untuk penilaian ergonomik. Walau bagaimanapun, terdapat beberapa faktor yang mempengaruhi kesukaran penilaian itu, seperti yang subjektiviti keselesaan, kos yang tinggi sistem mock-up dan alat berkomputer, dan kelemahan menyusun semula pelarasan. Sistem yang dicadangkan membenarkan pengguna atau jurutera untuk mendapatkan model visual tiga dimensi dengan bantuan peralatan tambahan yang termasuk kepala Augmented Reality dipasang paparan untuk mengurangkan komponen prototaip fizikal. Pengguna atau jurutera dapat menentukan kedudukan komponen dalaman untuk menentukan ergonomik zon mencapai yang paling selesa.

Kata kunci: Reka bentuk ergonomik kereta; realiti diperkukuhkan; pembangunan

1.0 INTRODUCTION

1.1 Vehicle Ergonomic

Nowadays, human factor studies are required in the engineering, designing, creation and support of new and advance systems. Driving simulators have provided sufficient evidence into the impacts on driving performance of alcohol, distraction, social drugs, fatigue and new vehicle technologies [1]. There is much proof to recommend that a critical number of street mishaps happen while the driver's advertence is centred on the operation of in-car gadgets [2]. Creating in-car gadgets that can be worked inside appropriate safety bound is an ergonomic issue. While ergonomics may have the obligation regarding deciding and distinguishing operational criteria, it is a design issue when auto gadgets are not able to meet such criteria [3]. Hence, to prioritize the comfort of the drivers and travellers, determining the position of all automated control parts in a car's interior configuration according to the driver's perspective is a necessity to understand the user's reachability and approachability in controlling and minimizing the driver's weariness [4]. The automotive industry realized that ergonomics and car interior design become the main validation content in new concept car development. A car interior configuration can essentially influence the sensibility of drivers in terms of the comfort or distress level. In the field of vehicle ergonomics, different tools and strategies have been developed to help engineers in assessing and enhancing vehicle interior configuration regarding feasibility, driver comfort and desired position of car components [5]. However, there are always difficulties in carrying out the vehicle ergonomic evaluation. Firstly, it is impossible for different drivers to have absolutely same opinions regarding the comfort experienced in the same car. This is because feeling of comfort is very subjective and it varies between people. Adding on, a person's idea on comfort may likewise change after some time [6]. Second, computerized tools such as hardware, software and technical support for ergonomic evaluation is often costly as well and requires skill and knowledge in computers and ergonomics to operate them [7]. Third, regarding cost, each physical mock-up system is specific for certain car types; sedan or MPV. Since the specific mock-ups are unacceptable for other vehicle sorts, a few mock-ups needs to be fabricated for each vehicle [8]. Finally, there exists a disadvantage in configuring adjustments and re-examinations. In a mock-up test, it is important to return to the design procedure to make change when design issues are discovered, and afterward the same procedures will be rehashed to be updated and reconsidered. This will normally take a few iteration cycles to obtain a suitable design [8].

1.2 Augmented Reality

Usually a lot of tests need to be carried out during the designing stage of a new product such as assembly inspection, layout inspection and so on. However, all these inspections can be carried out using digital prototyping tools, which are commonly applied in automotive, aerospace and naval designs [9]. Chrysler Corporation was one of the first companies to use digital mock-up with its own developed software, Chrysler Data Visualizer (CDV). This system was able to reduce the model development cycle significantly, and resolve thousands of issue before building the first test vehicle [10].

Augmented Reality (AR) is a newly emerging technology which superimposes computer generated virtual 3D images, texts, and information onto the real world [11]. AR involved a real-time view of the user's environment as the background and couples it with the virtual image to create a partially synthetic view that is presented on the scene of the user's view [12]. AR can also be defined as the "middle ground" between Virtual Reality and tele-presence since it only supplements reality instead of completely replacing it with a virtual environment [13]. AR improves and alters reality by adding desired virtual objects and requires high accuracy in tracking [14]. AR also allows users to feel more immersed with the real environment by superimposing virtual objects onto the real environment to create a mixed reality [15]. Basically, AR systems consist of two primary activities: tracking, where the location and orientation of the camera relative to the real world environment is calculated, and registration, where the virtual 3D objects are superimposed onto the user's view depending on the data calculated from the tracking process [16].

AR technology can be categorize into 2 types; marker-based AR and markerless AR. Marker-based AR can also be divided into 2 categories based on their application; image-based and location-based AR. Image-based AR requires specific marker or label to register the position of virtual images on the real world environment. On other hand, location-based AR uses position data, usually a data from global positioning systems (GPS) to appraise the location [17]. For markerless AR, the tracking system for the machine learning algorithms are based on image processing. It allow the virtual objects to remain at the correct position relative to the user's face under any movement [18].

2.0 PROPOSED SYSTEM

Augmented Reality technology becomes an important approach for designing the stage in automobile fields. This technology will reduce the time to design a good car interior prototype since it allows rapid modifications. Adding on, material waste can be minimized without building physical prototypes. Therefore, this research aims to introduce a new Augmented Reality approach to car ergonomic assessment of driver vehicle package design. The proposed system allows the user or engineer to obtain the three-dimensional visual model with the aid of additional equipment that includes a head mounted display to replace a physical prototype.

Moreover, this system allow the user or engineer to rearrange the position and orientation of the interior components in real time easily without building a prototype. The user or engineer can optimize their design finalization process through this system and then build the prototype with this low cost system. The user or engineer is able to evaluate the position of any interior components to determine the most comfortable ergonomic reaching zone.

3.0 SYSTEM FLOW

In order to conduct this project in a more systematic manner, a system flow chart as shown in Figure 1 was generated to complete the tasks procedurally.

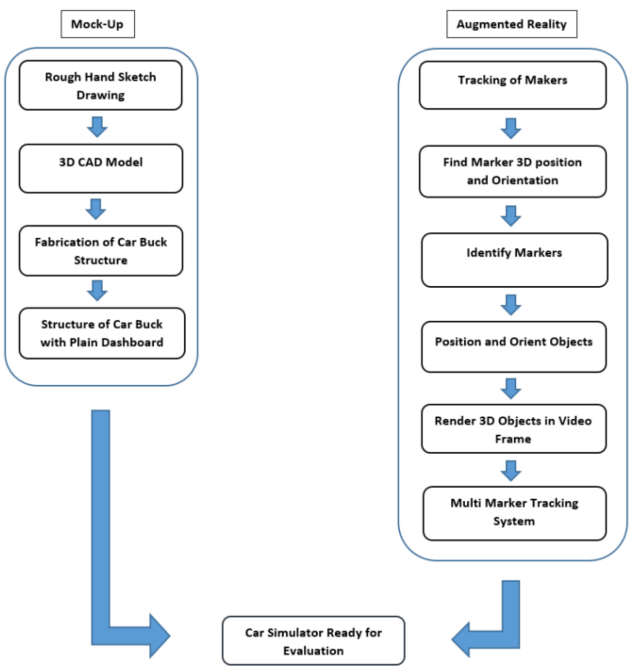


Figure 1 System flow chart

4.0 HARDWARE SETUP

A 3D car driving bulk CAD model was designed using SolidWorks 2013 CAD software to improve the quality of the design. A good and detail CAD model will benefit the fabrication process by reducing errors in fabrication and time consumption. However, the dashboard of this driving bulk is just a white flat surface without any real car components. The car components will be added to the empty dashboard using Augmented Reality technology. Figure 2 *and* Figure 3 shows the side view and the isometric view of the car driving bulk CAD model respectively. The isomeric view of the real car driving bulk can be seen at Figure 4 whereas Figure 5 shows the side view.

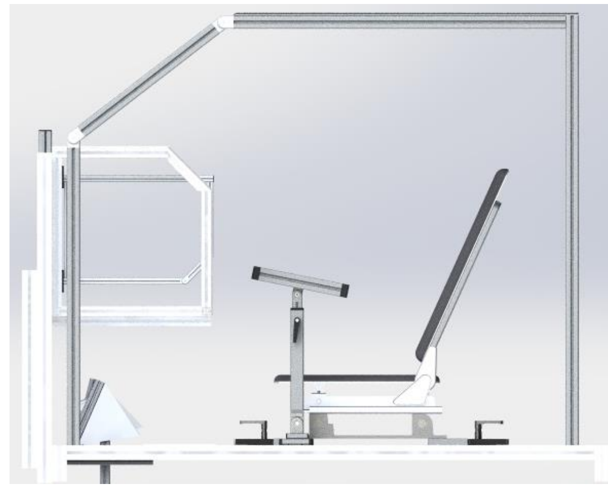


Figure 2 3D car driving bulk CAD drawing (side view)

Figure 3 3D car driving bulk CAD drawing (Isometric view)

Figure 4 Real car driving bulk (Isometric view)

Figure 5 Real car driving bulk (side view)

5.0 SOFTWARE SETUP

It is known that many researches and applications of AR has been conducted in various fields. In some of the sources, ARToolKit was mentioned and recommended to ease developers in developing AR applications. Therefore, ARToolKit is chosen as the open source library.

The setup process of the toolkit needs to be understood so that the developed program is able to calculate the position and orientation relation between the target marker and reference marker. Matrix will be used in the program to determine the position and orientation between the markers. Some specific markers which can only recognized by ARToolKit will be placed on the white flat dashboard while ensuring that the webcam is able to have a clear view. Wrong positioning of the webcam will influence the tracking of markers. Therefore, the webcam or HMD must be placed in a desired position to increase the performance of the AR software to ensure smooth tracking.

5.1 Virtual Steering Wheel On The Specific Marker

A 3D car steering wheel is designed using SolidWorks 2013 and saved as stereolithography (STL) format. This CAD model is then imported into ARToolKit and then registered on a specific marker. *Figure* 6 shows the flow of how ARtoolKit works. The webcam is used to stream the video from the actual environment while AR HMD is used to display the video after the environment is superimposed with the virtual objects.

Figure 6 The flow chart of how ARToolkit works.

5.2 Multi-Markers Tracking

Figure 7 shown the multi-markers tracking method used in this system. Usually, one marker is sufficient for tracking. However, the tracking will fail when some sections of the marker is covered. The registration of the virtual image will fail as well when the webcam is not able to track the marker. Therefore, multi-marker tracking is used to increase the performance of this system. The virtual object can still be registered even with the specific marker is partially or even fully covered. This is because the webcam is still able to track other markers, hence the registration of the virtual object will not fail.

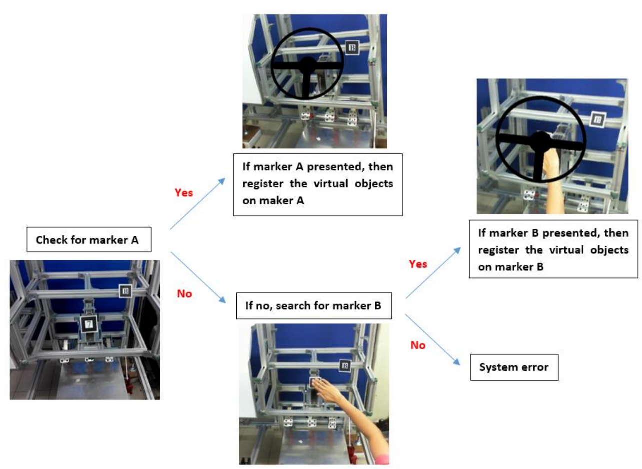


Figure 7 Multi-markers tracking

6.0 VALIDATION FOR THE ACCURACY OF AR SYSTEM

A validation test for the accuracy of this AR system has been carried out by comparing an actual rectangular box with a virtual rectangular box. A virtual rectangular box with 9.3cm (width) x 5.0cm (height) x 13.2cm (depth) which is the same size with the actual box is modelled using SolidWorks 2013. After that, the model is imported into ARToolKit and measured with a ruler. Figure 8 shown that the width of the virtual box is 9.3cm while Figure 9 shows that the height of the virtual box is 4.9cm. Lastly, the depth of the virtual box is measured as 13.1cm in Figure 10. Figure 11 shows the virtual box placed beside the actual box.

Figure 8 Virtual rectangular box (width measurement)

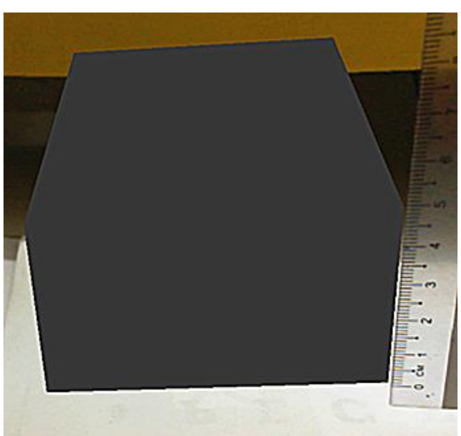


Figure 9 Virtual rectangular box (height measurement)

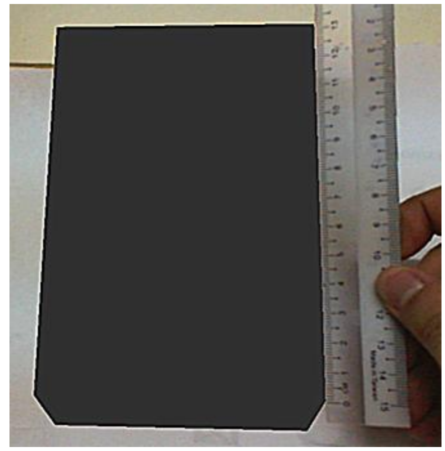


Figure 10 Virtual rectangular box (depth measurement)

Figure 11 Virtual box and actual box

After the measurement for the virtual rectangular box is taken, we can conclude that the accuracy of ARToolKit is high and this AR system is validated.

7.0 FUTURE WORKS

A group of subjects will be involved in the ergonomic quantitative data collection such as ergonomic reaching zone and user comfortability using this system.

8.0 ACKNOWLEDGEMENT

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