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MEMS Gyroscope Based Motion Sickness Estimation System using Car Travelling in 3D Space

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Abstract

A creative and initial work focused on designing a system to estimate motion sickness occurs during travelling. Motion sickness is a condition in which a disagreement exists between visually perceived movement and the vestibular system's sense of movement. To reduce possibilities of visually-induced motion sickness caused by animations, video games and movies, there is a need to develop an evaluation method of visually-induced motion sickness. A mathematical simulink model is built to simulate motion sickness and to simulate the severity of motion sickness using driver's seat movements measured in the real-car experiments. From these results, it is expected that the device has an effect to reduce MSI, and also this device has an effect to decrease carsickness.

The paper is focused on estimating MSI (Motion Sickness Incidence) from the simulink model for 360 DOF (degrees-of-freedom) in the 3D (dimensional) space. MEMS (Micro Electro Mechanical System) gyroscope based MSI control device is proposed and is implemented. This evaluation system can be applied to early detect the subject's motion sickness level and prevent the uncomfortable syndromes occurred in advance in our daily life.

Keywords: *Motion sickness, carsickness, head movement, posture control device.*

1. Introduction

Car sickness decreases comfort of humans in a vehicle. It is necessary to clarify its mechanism and to develop a reduction method. Many research studies have been conducted on motion sickness. Experiments involving human exposure to whole-body vibration were conducted to examine the susceptibility to motion sickness under vibrations at various frequencies [4]. The head movements of the driver and the passenger relate to the motion sickness while there are other interpretations include obtaining better visual information. Therefore, it is thought that the systematic methodology to reduce motion sickness can be established by investigating relationship between driver's head-tilt strategy and susceptibility to motion sickness [8].

The present study shows that the effect to reduce motion sickness is by investigating the MSI using the mathematical simulink model. The simulink model is developed based on existing 6DOF-SVC model and a new model is proposed with 360DOF [6]. Using this model, MSI value is calculated with some threshold value. Based on the results, it is aimed at reduction of motion sickness by controlling the posture during car driving. A mathematical model has been introduced for motion sickness that can estimate MSI in 360 DOF motion.

The main organization of the paper includes the following (i) System is implemented with 360 DOF (degrees -of-freedom) (ii) Angle measured with 3D coordinates(iii)Estimate MSI using model of the platform(iv)Enhance the process by using Micro Electro Mechanical device (MEMS).

2. Related Works

There are several methodology has been proposed. However, the proposed methods involve difficulties in estimating MSI. This section addresses various limitations of different methods.

The contribution to motion sickness of visual feedback on head roll and of stereoscopic view was capable of motion in all three rotational degrees-of-freedom [1]. Many motion sickness-related biomarkers have been identified; estimating human's motion sickness level (MSL) remains a challenge in operational environments. A physiology-based estimation system has been proposed that can automatically assess subject's motion-sickness level [2]. Sensory conflict theory has become the most widely accepted theorem of motion-sickness on a moving boat, train, airplane, car, or amusement park rides [3]. Motion sickness becomes a very important issue in our daily life especially considering driving safety. Many attempts have been undergone to realize motion sickness, and detect it and so a virtual-reality (VR) based driving environment with instinct MSL-reporting mechanism has been introduced [4]. A mathematical model is build for the motion sickness and simulates the severity of motion sickness using driver's head movement for the real-car experiments hence a posture control device is proposed [6]. Motion sickness incidence caused by the head movement in 3D space based on subjective vertical conflict analyzes the effect of head movement by decreasing motion sickness incidence model. Car drivers receive the acceleration simulation and the rotational simulation such that motion sickness is greatly reduced [8]. The human exposure to vibration is increasingly the subject of health and safety legislation, legislation which can be applied to high speed craft [9].

3. Motion Sickness

Motion sickness or kinetosis is known as travel sickness. Motion sickness is an unpleasant condition, which many people experience at some point in their life. The most common forms of motion sickness occur during the course of travel on ships, small boats, cars, aero planes and buses. Motion sickness is a common experience of numerous people. The symptoms of motion sickness are headache, sweating, disorientation, postural instability, dizziness, nausea and vomiting. Motion sickness occurs when the brain receives conflicting sensory information from body, inner ear and eyes. Therefore motion sickness becomes a very important issue in our daily life especially considering driving safety.

3.1 Types of Motion Sickness

The types of Motion sickness mentioned in various sources includes

3.1.1 Car sickness

Car sickness is a specific form of motion sickness and is quite common and often evidenced by the inability to read a map or book during travel. Car sickness results from the sensory conflict arising in the brain from differing sensory inputs.

3.1.2 Air sickness

Air sickness is a sensation which is induced by air travel. It is a specific form of motion sickness and is considered a normal response in healthy individuals. Airsickness occurs when the Central nervous system receives conflicting messages from the body.

3.1.3 Sea sickness

Sea sickness is a form of motion sickness characterized by a feeling of nausea and, in extreme cases, vertigo experienced after spending time on a craft on water. It is, again, essentially the same as carsickness, though the motion of a watercraft tends to be more constant.

4. Motion Sickness Simulation

4.1 Mathematical simulink model of motion sickness

In this mathematical model, 360 DOF is considered. Sample Input is the set of predefined data for a car travel. This data contains all the turns and rotations to show the MSI Calculation. Control unit convert all data to required data to control the animation car. Animation control is existing mat lab setup and is used for animation purpose.MSI Calculation is for calculate the MSI and the paper model is used for calculating the MSI. The constant are found by trial and error method till the graph is obtained.

The pre-computed simulation data representing one lap of a vehicle on a testing circuit is converted from dynamic model signal structure into the form that can be sent to the virtual reality scene. This conversion includes splitting the combined signals into signals governing individual VRML (Virtual reality modeling language) objects properties and coordinate systems transformations. The data is then sent to the virtual reality scene using VR Sink block with sample rate 25 Hz.

The dynamic model provides not only signals that influence visual properties of objects (positions and rotations), but also forces and other similar quantities, that can be visualized as well. In this example, wheel forces are visualized using VRML triads scaled dynamically according to current force values. Force triads can be switched off by the Forces Visibility Switch. When working with virtual reality models, there is a common requirement to track certain moving objects with the camera.

Usually, the direction from the camera to the object is easily available (both positions are known, so direction from the camera to the object is defined as the difference between the two positions).Because in VRML the viewpoint orientation is defined in the form of 4-element (axis angle) VRML rotation, camera direction must be converted into this format before sending to virtual scene.

Simulink 3D Animation provides the Viewpoint Direction to VRML Orientation block to perform this conversion. In this example, switch to the Simulink Controlled Viewpoint in the viewer to see the camera tracking effect. The mathematical simulink block diagram for MSI calculation is shown in figure 1.

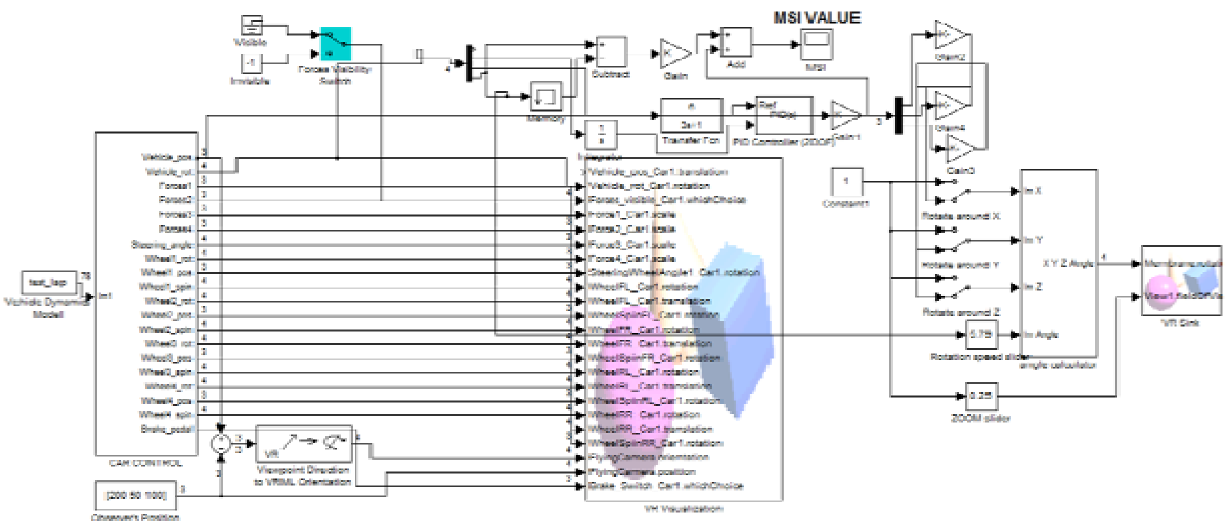

Fig. 1 Simulink block diagram for MSI calculation.

5. Architectural Design

The figure 2 shows the architectural block diagram. 3-axis accelerometer is the MEMS sensor and is used for movement of the seat. The outputs (x,y,z) from the MEMS sensor in analog form is sensed to the microcontroller with 10 bit ADC.10 bit ADC has high resolution and the operation is faster. The analog from microcontroller gets converted to digital.MSI value is already fixed to some particular threshold. If the value varies after the threshold, new MSI value is calculated and tuned and is displayed using 16x2 LCD display. The 5v from the microcontroller is converted to 12v by the driver circuit. The driver unit ULN 2003 is used because of low power. The PWM control unit is connected to the servomotor for angle measurement. The servomotor is hence used for controlling the base of the car and hence the angle is tilted.

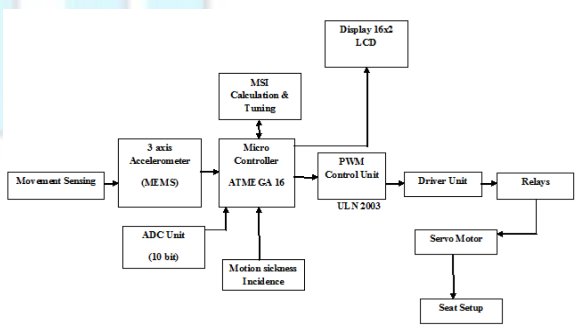

Fig.2 Architectural design

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a

minimum full-scale range of ±3 *g*. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The ADXL335 is available in a small, low profile, 4 mm x 4 mm x 1.45 mm, 16-lead, plastic lead frame chip scale package (LFCSP_LQ). The ATmega16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC
architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

6. Results and Analysis

6.1 Simulation results

The simulation is done with MATLAB (simulink). MATLAB is a programming language developed by Math Works. It is started out as a matrix programming language where linear algebra programming was simple. It can be run both under interactive sessions and as a batch job. Most MATLAB scripts and functions can be run in the open source program octave. This is freely available for most computing platforms.

Simulink, developed by Math Works, is a commercial tool for modeling, simulating and analyzing multidomain dynamic systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. It offers tight integration with the rest of the MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in control theory and digital signal processing for multidomain simulation and Model-Based Design.

Simulink provides a graphical user interface (GUI) that is used in building block diagrams, performing simulations, as well as analyzing results. In Simulink, models are hierarchical can view a system at a high level, and then double-click on blocks by using the mouse to go down through the design levels.

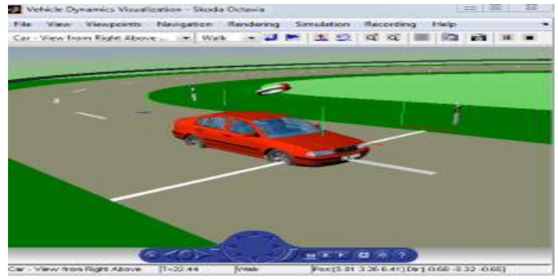

Fig. 3 Control unit.

The figure 3 gives the real situation inside the car and the related forces created inside the vehicle. The car shown in the output is the control unit and this has the whole control of the system.

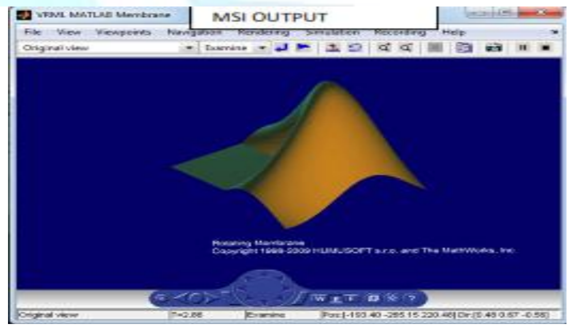

Fig. 4 MATLAB membrane.

The figure 4 shows the animation control as the existing MATLAB setup used for animation purpose. The MATLAB symbol is taken as the output to explain the adjustment of the seat automatically for the forces created.

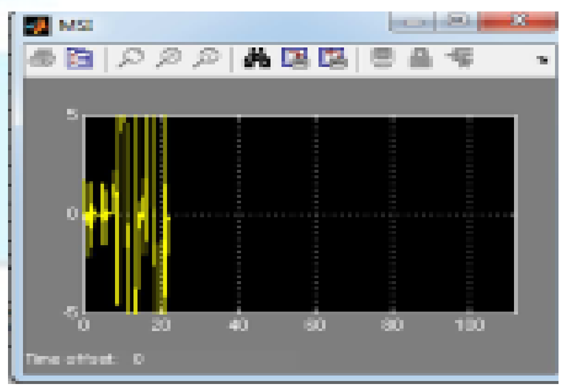

Fig. 5 MSI output.

The figure 5 shows the graph with calculated MSI value and is varied. This is the required output where the car direction and angle tilt is the input and graph show the variation of MSI. With this obtained

MSI, the car seat is controlled. Thus the motion sickness is controlled.

6.2 Proteus simulation result

Proteus is software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. It is developed by Lab center Electronics. The main System components of Proteus include ISIS Schematic Capture, PROSPICE Mixed mode SPICE simulation, ARES PCB Layout, VSM, System benefits.

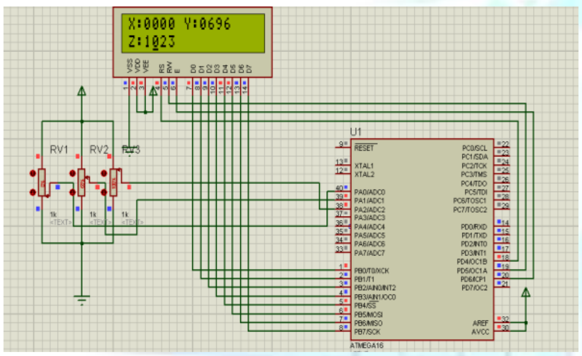

Fig. 6 Proteus design suite.

The figure 6 represents the Proteus simulation design suite model with 2 X 16 LCD display, ATMEGA 16 and three variable resistors. The 3D co-ordinates corresponding (X, Y, Z) are determined as shown in the figure. The main aim of this Proteus design is to verify the architectural design. The 3 variable resistors (RV1, RV2, and RV3) correspond to 3 axis accelerometer with 3D space.

7. Conclusion and Future Scope

A mathematical model of motion sickness is introduced to investigate the relationship between the seat movement and the motion sickness. It is shown that the driver's seat movement has an effect to reduce motion sickness by investigating the motion sickness incidence in the different seat movement using the model. Based on the results, posture control device is developed to reduce the passenger's motion sickness by inducing the head movement toward drivers. From the verification experiment for the effect of the device, the head-roll angle of most passengers decreased in the curve running with the device except for the large acceleration situation. From these results, it is expected that the device has an effect to reduce MSI, and this device has an effect to decrease carsickness. The subjective assessments showed that the device was effect to increase stability of the posture and increase the comfort in curve driving.

As for the future study, the onset timing and the location of the device will be investigated in more detail so that the passengers tilt their seat like the drivers without an uncomfortable feeling. In addition, it is also investigated that the effect of the system from the viewpoint of postural maintenance of the driver as well as the decrease of the motion sickness to realize comfortable vehicle motion. Based on the results, a MEMS (Micro Electro Mechanical System) gyroscope based MSI control device is proposed and is implemented. An electro-mechanical system is implemented which keeps the patient away from the sickness. The evaluation system can be applied to early detect the subject's motion sickness level and prevent the uncomfortable syndromes.

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