Design and development of driving external support for lower limb disable patients

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Abstract. The driver who lower limb disabled patients were used the hand control to drive. The hand control was fixed permanently on the pedals. Thus, their family cannot share the car with them. Hence, there are several ways to innovate the hand control become portable product. This study was undertaken to investigate the characteristic driving behaviour of lower limb disabled patient yet to establish the design driving external support that was portable by using hand control. There are many types of mechanism that was used to upgrade the product function compare to existing product. The materials mainly used steel as the materials of hand control stick. The fabrication process was used two weeks to done the prototype. Using a novel upgrading of portable hand control may help the disable patient easily use the fingers and hand, without using any tools. This product also can be refit in others car. The innovation of mechanism assists patients can share their car with their family members.

1. Introduction
Driving is a complex task because it needs some skills and steps to control it such as sound recognition, perceptual, motor skills and also on environment and mechanical factors. It should be investigated the factors that cause the accident. Besides, the driving task can become isolate specific components to observe the situation such as vision requirements, eye movements, perceptual skills and decision-making. It was identified over 1500 driver join in the analysis that was done by McKnight and Adams, 2009. The analysis focus on human performance which the most important factors in driving skills and reported that, it was 90 % of human error considers as the cause of accidents. Attention, perception, and information processing was the dominant of human error (Pac, Centre, & Britain, n.d.). Besides, some disabled patients were desire to drive because driving was the basic for the jobs who was physically disabled. Disable patients facing problems while drive a standard car because high cortical deficit which the main problem affects them to drive safety [5]. Normally, accelerating and braking in a standard car is usually done using foot pedals. But, for disable drivers, it was difficult to control the foot pedal, and need an automobile hand control to solve the problems. Driving performance between disabled drivers and normal drivers are same. However, for the physical effort, the disabled driver needs greater effort than non-disabled drivers. Thus, improving of the design supports was important, which make the drivers to be aware of their benefits and to increase their confident by using the kind of products [3]. From study done by Bruce 2005, stated that the disable patients as well as disable drivers unable to use their legs to operate the brake and accelerate pedals.
Additionally, there was less production vehicles developed to account for physically disable drivers. Hence for the future, there must have an alternative hand control support which provides the greatest ability for disable drivers to control the vehicle braking and accelerating the car. Significant efforts and innovations are required to ensure that disabled patients can be provided with an aid adapted to their needs. These innovations can be technical or economic systems designed to enable disabled patients have a satisfying life as well as the improvements in assessment techniques and driving tuition [4].

Figure 1. The perspective view of one type of prior art vehicle control system [2].

2. Materials and methods

Figure 2 shows research framework of designing portable hand control. First, the difficulties facing by disable drivers need to observe and listed. Second, after observation has been done, it was found that the disable patients need to use hand control that fixed in the car to control the brake and pedal. Thus, this research needs to design a portable hand control (particularly for lower limb disable drivers) for giving easiest driving for disable drivers.
Lower Limb Disabled Patients have two types; (1) leg amputations patients (2) lower limb inability.

Two types of the patients can drive by using hand control after approve by doctor.

Research Gap

High expenses for disable patients to modify existing car.

Research Objective

To innovate and design a driving external support that was portable by using hand control.

Phase 1: Design of portable hand control using solidworks

Phase 2: Choose materials of portable hand

Phase 3: Verification model using simulation method

Analytical valid?

Objective 1

Objective 2

Phase 4: Finish prototype

Phase 5: Result interpretation

End

Figure 2. Research framework in designing hand control for disable drivers.
A mock-up of the portable hand control needs to consider in order showing the mechanism of the model, which focus on the adjustable length for portable hand control. Three-dimensional modelling (3D) has been used using SolidWorks software. The model has 26 parts, consist of handle, steel rod, screw nut, butterfly nut, clamp bar and iron chain in Figure 3.

![Model of the portable hand control](image)

**Figure 3.** Example features of screw and part of brake model using SolidWorks in 3D modelling.

The result from the model, next to be plotted using von Mises to obtain a maximum value which support the load using stress analysis. The stress analysis result has been compared with value of yield strength of the materials to verify the safety of the product. Next, the model needs to fabricate after selection material was done; by using stainless steel as the main material of the product. From stress analysis, yield strength of the model was 370 MPa, with Young modulus of steel 200 x 10^9 N/m², while the existence steel was 193 x 10^9 N/m² and yield strength 215 MPa.

### 2.1. Design finalizing

The design of portable hand control, at the first it must consider the condition of user that was lower limb disabled patients especially the leg amputation patients. The user was impractical to move, thus the main things of the weight of the product must be light and easy to take. The total weight of the prototype was 2.34 kg, the weight of brake hand control was 1.255 kg hook with steel chain and the weight of oil hand control was 1.085 kg that was lighter than brake control. Therefore, this was proved that the portable hand control can be taken by physically disabled patients. Thus, the length of portable hand control must be in the range of 50 cm – 100 cm. Each person adjusts the length of portable hand control was differently, so the design of the length was suitable to all patients. The longest length of the portable hand control can be adjusted in the range 93 cm – 95 cm and for the shortest length of the portable hand control was between 57 cm – 59 cm. The people can adjust the length of portable hand control until can comfortable to control it.

| Parts | Weight (kg) | Prototype model | Brake hand control | Oil hand control |
|-------|-------------|-----------------|-------------------|-----------------|
| Length (cm) | Portable hand control | Longest | 93 – 95 | Shortest | 57 – 59 |
| | 50 – 100 | | | |

### 2.2. Assembled prototype rendered by using Keyshot software

There has some specific characteristic of the portable hand control was attractive. There are have four part can disassembly, which are brake hollow steel rod, oil hollow steel rod, brake screw clamp and oil screw clamp as shown in Figure 4.
The force exerted on oil pedals and the brake pedals was different. The exerted force needs to push on the oil is smaller than the brake pedals. Even through the brake pedals and oil pedals is can bounce back, but if the hand control too heavy, it will cause the portable hand control exerted much force then cannot bounce back.

2.3. Simulations by using Abaqus
After apply the data given such as boundary condition and the load. Analysis was run and come out the result of displacement and stress. The condition of the body before was constrained, all section appeared in dark blue colour which mean they are free stress state or very low stress. The range of stress of dark blue colour is in between $6.912 \times 10^{-4}$ Pa to $4.537 \times 10^{-4}$ Pa. After constrained was show that in green colours. The range of green colour was $1.815$ Pa to $3.629$ Pa. The result of stress colour in the analysis are correct and the animation of the constrain performed in the Abaqus can be resulted accurate. The maximum magnitude was $7.375 \times 10^{-4}$ cm and the minimum magnitude was $0$ cm.
3. Results and discussion
The design requirement was based on the conducted questionnaire surveys and interview. All the data had been collected and analyzed to achieve the objectives of this project and solve the problem statement of the product. The product was portable and can easily take to everywhere attractiveness of the product. If compare to the hand control in the market the differences were the hand control in the market must fixed permanently in the car just can operate. In this state, if using portable hand control then the lower limb disabled patients can share car with their family because the installation was temporary. The final concept of sketches is proceeded to 3D modeling using SolidWorks software and by simulation of Abaqus software. SolidWorks was assembly 26 parts and used Keyshot software to render. The prototype testing was done in half hour to test the performance of the product. As expectation, the testing prototype was successful, it can be seen that the pushing the oil hand control used not much force and the brake hand control was release back was quickly. The making process was using two weeks to finish done the prototype. Finally, in this project two objectives were archived, the first one is investigating the driving behaviour of the lower limb disabled patients and the second objective was design the driving external support was portable by using hand control.

4. References
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