A. Title Page

Development of an Automated CRUSH Profile Measuring System

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B. Restatement of problem researched, creative work, or professional enhancement opportunity

Traffic accidents have become a serious social problem that threatens people and their property. In the United States, motor vehicle accidents are the leading cause of death for college age people.[1] Globally, traffic accidents are the second leading cause of death for young people between the ages of 18-25.[2] As a result vehicle safety design has made great strides during the last 20 years. Crumple zones, air bags, anti-lock brakes, and safety data recorders were direct results of control crash test and real-world accident investigations.

One analysis technique involves calculating the amount of energy dissipated during a collision. This technique is known as Crush Energy Analysis and has led to several improvements in vehicle safety design, namely the inclusion of crumple zones in critical structural areas. To perform Crush calculations the investigator must take a series of evenly spaced damage measurements to establish the amount of deformation the car experienced during a collision. These measurements must be very precise because the energy calculated using this data is extremely sensitive to variations in the damage depth (Energy ~ Damage Depth Squared), consequently, small measurement inaccuracies will result in large errors in these calculated energies. An example of these types of measurements are shown in Figure 1.[4]

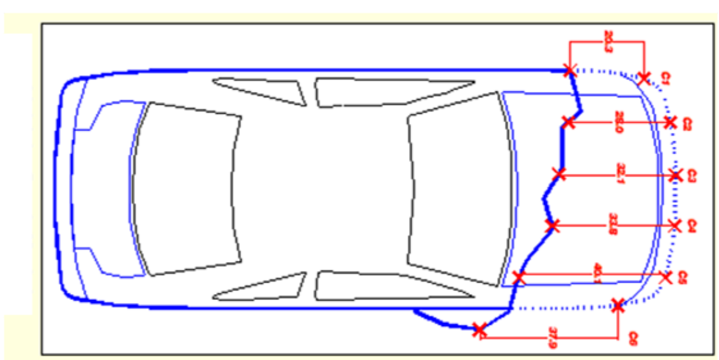

Figure 1 CRUSH measurements for a head-on collision

One major drawback with CRUSH analysis is the time it takes to perform the measurements. It can take an investigator several hours to setup and measure the vehicle because it is necessary to measure the entire vehicle in at least three separate planes of damage. Additionally it is necessary to reproduce the measurements on an exemplar undamaged vehicle in order to perform the calculations. Furthermore, in order to ensure the accuracy of the data it is often necessary to have a team of 2-3 investigators/engineers. What is needed is a simple, fast, and highly accurate method for collecting these measurements. In this proposal we request funds to design an automated system that would scan the front or side of a vehicle and record the damage profile in a matter of minutes instead of hours. Additionally the system should be portable and simple enough to be operated by only one user.

C. Brief review of the professional enhancement opportunity, creative work, or research procedure

We tried two competing designs. The first consisted of a Light Detection and Ranging system (LIDAR) mounted on a tripod. The LIDAR works by sweeping a laser over 240° with 0.36° angular resolution. As the laser scans it simultaneously detects reflected signals and calculates the distance as a function of angular position. This scan is completed in under a second and is accurate to within +/- 0.1 inch. The LIDAR system was then mounted on a lightweight aluminum tripod stand. This stand allows the investigator the ability to take scans at multiple heights in order to obtain a complete CRUSH depth profile.

The second design consisted of a laser range finder mounted on a stepper motor. The laser range finder detects the distance to a point directly ahead of the system. The design would work by first using the range finder to calculate a distance then the stepper motor would move over 0.25” and the range finder would find another distance. The entire operation is controlled using a microcontroller. The data is saved to a Micro SD card in a two column format that can be loaded into excel for analysis.

D. Summary of findings, outcomes, or experiences had.

We found that both designs produce highly accurate results. The second design, incorporating the laser range finder and stepper motor, had a few flaws. First the system needed a long support structure to span the length of a car. These supports were bulky and difficult for one person to setup. Secondly, the time for the second design to scan an entire car was quite long (~20 – 30 minutes). This is because the system would step forward and take a data point every 0.25”. The typical length for a car is around 10-12 ft. resulting in around 480 – 580 data points for one side. The third major flaw of the system is the cost. An accurate laser range finder with good outdoor performance cost almost $3,000. If the system were to be commercialized it would cost between $6k-$10k. One advantage of this design is that the data was accessible and easy to interpret.

Our first design, using the LIDAR system, was a highly portable, user-friendly, and accurate system. Additionally, it did not require any bulky support system so the user could easily set it up alone. One problem with this design is that the data is not so user friendly. This is because the data is given as a function of angle and not simply distance. This could be fixed by writing some additional software but that too would result in additional costs. The major drawback to these advantages is the cost. The LIDAR system alone cost ~$2,000. If we were to commercialize this system it would retail for approximately $4k-$6k. Although it performs extremely well the system is too cost prohibited.

E. Conclusions and recommendations

In conclusion our two designs were both highly accurate. The LIDAR design was also very portable and with some extra work the data could be made easy to interpret. Unfortunately both designs were cost prohibited. We are currently exploring a sort of homemade LIDAR system. This system would have close to the same accuracy level as a production LIDAR but would cost considerably less.

REFERENCES

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3. Center for Disease Control, “The Incidence and Economic Burden of Injury in the United States”, http://www.cdc.gov/ncipc/factsheets/CostBook/Economic_Burden_of_Injury.htm
4. http://www.exhibit-a.net/vehicle/