Embedded Systems and Instrumentation Laboratory

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Embedded Projects

• Development of an Embedded System for Measuring 3-D Profile using a Scanning Laser
• An Embedded Control System for Real-time Data acquisition and processing on a mobile platform - Push Cart Profiler
• An Embedded System for Real-time Data acquisition and computation of surface profile on a mobile platform floating on wet concrete - Sliding Profiler
Embedded Projects

• An Embedded Real-Time High Speed Profiler
• Cross Slope Measurement
• Model Development for computing a New Surface Roughness Index - New Surface Index Analysis
• Design and development of an embedded Method for detecting bridge movements
Scanning Laser Project

- A Scanning Laser is mounted on a vehicle, and used to capture a three-dimensional image of a pavement surface.
Mobile Profiler

Push Cart Profiler

- The Push Cart Profiler is a device that allows a power pack, note book, and an array of sensors to be tested at walking speeds over a surface.
- Gyroscopes, 2-Dimensional Gyroscopes, 3-Dimensional Gyroscopes, and Inclinometers can all be attached to the swing arm of the cart for testing different targets.
- An encoder is used to handle tracking the location of the push cart and the data.
A new device called the Sliding Profiler is now a working prototype, and is designed to find deformities such as bumps in concrete before it hardens.
High Speed Profiler

- The Profilometer is a sensor array consisting of several sub components mounted on a sensor van.
- The wheelpaths of a moving vehicle are scanned by a laser and adjusted using an accelerometer to capture the surface parallel to the vehicle.
- The width of the vehicle can be scanned using a set of lasers or acoustic sensors to capture the surface perpendicular to the path of the vehicle.
- The Profilometer can operate at 60 mph.
An Embedded System for Computing Cross Slope

Cross Slope Measurement

- Roadways are given a 2% Cross Slope when they are built in order to facilitate runoff and keep the surface dry. Being able to measure a Cross Slope quickly and for significant distances requires an embedded instrument system using either lasers or gyroscopes.
Modeling New Profile Roughness Index

**New Serviceability Index (NSI)**

- One important statistic is the Serviceability Index or ride equation, which is a measure of how smoothly a vehicle travels over a surface. An update of this index has been developed, and is now being used for measuring ride.
A Template Analysis Procedure

**Template Analysis**

- While studying the new ride equation, it became apparent that localized problems, such as this pothole, could be identified. A new template analysis procedure (TAP) has been developed based on NSI by locating areas on pavements with bumps effecting ride.
3D Bridge Monitoring System
Feasibility Study
Objective:

• The objective of the proposed research is to explore the feasibility of developing a portable integrated embedded framework that can be used to proactively monitor and analyze bridge profiles in a periodic manner by collecting and processing 3-D bridge approach, and deck surface profile and synchronizing this profile with video images of bridge structures.
TIL Team

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Major System Modules

• Embedded Transverse Profile System
• Video Control System for Monitoring and Synchronizing Video and Surface Profile
• Structure Image Capture and Processing Process
Need for Bridge Monitoring

• Bridges are an important part of the road network.
• Failures in bridge structures can occur due to wear and tear, corrosion etc causing huge loss of life and property.
• This can be avoided by routinely monitoring the bridge structures and scheduling maintenance if abnormal movement is detected.
Road Profiling

- The first part of the bridge monitoring system is calculating the road profile.
- The road profile can be calculated using inertial profilers.
RoLine Line Laser

- Unlike single point lasers, the RoLine laser has a wide footprint (4-5 in).
- Can be used for computing profiles with greater accuracy as it provides the true tire-road contact profile.
- To calculate longitudinal profiles, a *tire-bridging algorithm* is implemented to calculate an average, representative value of the tire-road contact.
- Two or more of such line lasers can be used together to obtain the transverse as well as longitudinal profiles in a single run.
- Thus, the entire 3D profile could be computed using these lasers.
3D Bridge Monitoring system

- The video data from the camera is used for identifying the structures of the bridge and it is to be integrated with the 3D road surface to form a complete 3D structure of the bridge.
System Setup

- Gyroscope
- Camera
- Gyroscope
- Wide line lasers
Video Control System for Monitoring and Synchronizing Video and Surface Profile

- There is a need for getting the video information of the bridge structures with minimum jitter while following the road profile.
- A control system is required for real time stabilization of camera platform.
- Simulation of the control system was done for verifying the feasibility of PID controllers for this application.
- Linear relationship is established between accelerometers on a straight line.
- This eliminates the need of accelerometer for each laser.
- Simulation of wide line laser was done for purpose of reconstructing the road profile in 3D.
Computer Vision Algorithm

- Compensating any Rotation &/or Translation using 3D Road Profile as Reference
- Image Registration and Matching
  - SIFT, SURF
- After Matching Rotation Compensation for View error
- Using LMSE Difference to detect any movement
Conclusion

• Current Methods are based on contact sensors, such as strain gauges and accelerometer.
• These sensors provide only temporal signature.
• These Methods require diligent procedure.
• A better robust procedure is proposed here.