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Transportation

**Federal Railroad
Administration**

Railroad Track Inspection Interface Demonstration

Office of Research,
Development,
and Technology
Washington, DC 20590



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13. ABSTRACT (Maximum 200 words) This project developed a track data user interface utilizing the Google Glass optical display device. The interface allows the user to recall data stored remotely and view the data on the Google Glass. The technical effort required developing a communication link between the Google Glass and a cellular telephone. Fulcrum Corp. demonstrated the interface between Google Glass and FRA's track geometry data housed at FRA Headquarters. The laboratory demonstration used a simulated section of track with simulated data that were subjected to enhanced tolerances to create exceptions (TRL 4). Future work would involve a validation of the interface in a relevant work environment, on actual tracks with experienced track inspectors (TRL 5).				
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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

- 1 inch (in) = 2.5 centimeters (cm)
- 1 foot (ft) = 30 centimeters (cm)
- 1 yard (yd) = 0.9 meter (m)
- 1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

- 1 square inch (sq in, in²) = 6.5 square centimeters (cm²)
- 1 square foot (sq ft, ft²) = 0.09 square meter (m²)
- 1 square yard (sq yd, yd²) = 0.8 square meter (m²)
- 1 square mile (sq mi, mi²) = 2.6 square kilometers (km²)
- 1 acre = 0.4 hectare (he) = 4,000 square meters (m²)

MASS - WEIGHT (APPROXIMATE)

- 1 ounce (oz) = 28 grams (gm)
- 1 pound (lb) = 0.45 kilogram (kg)
- 1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

- 1 teaspoon (tsp) = 5 milliliters (ml)
- 1 tablespoon (tbsp) = 15 milliliters (ml)
- 1 fluid ounce (fl oz) = 30 milliliters (ml)
- 1 cup (c) = 0.24 liter (l)
- 1 pint (pt) = 0.47 liter (l)
- 1 quart (qt) = 0.96 liter (l)
- 1 gallon (gal) = 3.8 liters (l)
- 1 cubic foot (cu ft, ft³) = 0.03 cubic meter (m³)
- 1 cubic yard (cu yd, yd³) = 0.76 cubic meter (m³)

TEMPERATURE (EXACT)

$$[(x-32)(5/9)] \text{ } ^\circ\text{F} = y \text{ } ^\circ\text{C}$$

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

- 1 millimeter (mm) = 0.04 inch (in)
- 1 centimeter (cm) = 0.4 inch (in)
- 1 meter (m) = 3.3 feet (ft)
- 1 meter (m) = 1.1 yards (yd)
- 1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

- 1 square centimeter (cm²) = 0.16 square inch (sq in, in²)
- 1 square meter (m²) = 1.2 square yards (sq yd, yd²)
- 1 square kilometer (km²) = 0.4 square mile (sq mi, mi²)
- 10,000 square meters (m²) = 1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

- 1 gram (gm) = 0.036 ounce (oz)
- 1 kilogram (kg) = 2.2 pounds (lb)
- 1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

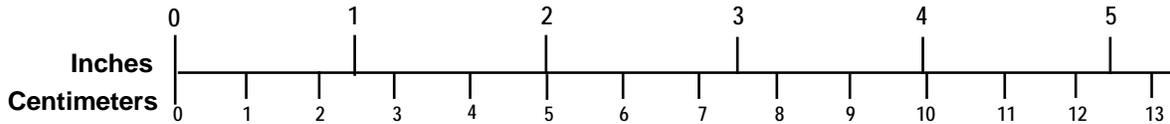
VOLUME (APPROXIMATE)

- 1 milliliter (ml) = 0.03 fluid ounce (fl oz)
- 1 liter (l) = 2.1 pints (pt)
- 1 liter (l) = 1.06 quarts (qt)
- 1 liter (l) = 0.26 gallon (gal)
- 1 cubic meter (m³) = 36 cubic feet (cu ft, ft³)
- 1 cubic meter (m³) = 1.3 cubic yards (cu yd, yd³)

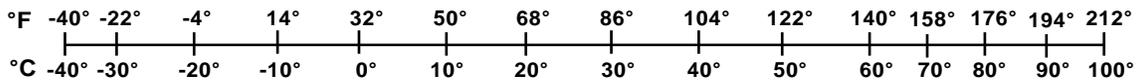
TEMPERATURE (EXACT)

$$[(9/5) y + 32] \text{ } ^\circ\text{C} = x \text{ } ^\circ\text{F}$$

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price \$2.50 SD Catalog No. C13 10286

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Executive Summary

Traditional railroad track inspection activities typically require an inspector to carry and use laptop computers, tablet devices, and/or large amounts of paperwork in order to have access to prior data. Using a laptop computer, or sifting through stacks of papers to easily locate and review previous measurement information, is cumbersome, time-consuming and is a potentially risky distraction for inspectors operating in the field.

In this project, Fulcrum Corp. developed a web-based application and a Google Glass application that demonstrated how Google Glass could be used to automatically retrieve and display relevant images and track geometry information based on the GPS location, as well as display and record new inspection data, and eliminate the need to hand-carry computers and paperwork. Fulcrum successfully demonstrated the web-based and Google Glass applications at the Federal Railroad Administration (FRA) on December 11, 2014 using synthesized scenarios and data.

After the in-house demonstration, future development tasks include selecting a track location for which digitized track geometry measurements and exception data exists; refining the web-based Google Glass applications in order to provide accurate geolocation and track data; and conducting a human factors investigation.

1. Introduction

The Federal Track Safety Standards (FTSS) require railroads to ensure that track meets or exceeds minimum federal safety standards. To complete this task, railroad inspectors must inspect the track at specified minimum frequencies based on the class of track, the type of track, the annual gross tonnage operated over the track, and type of train traffic. Track inspections are performed either manually or by automated machines like the Autonomous Track Geometry Measurement System (ATGMS). To carry out their tasks, inspectors must access prior data by using laptop computers and/or browsing through large amounts of paperwork, which is cumbersome, time-consuming and a potentially risky distraction for them.

Fulcrum demonstrated how Google Glass could be used (via a web-based application and a Google Glass application) to automatically display track pictures and track geometry information using a given Global Positioning System (GPS) location; display and record new inspection observation data; and eliminate the need to carry computers and paperwork in the field while performing the task.

Fulcrum's laboratory demonstration utilized track geometry from ENSCO, Inc., who served as a contractor for FRA. Data that could be displayed using Google Glass included track geometry, track repair history, previous inspection reports and data, incidents and accidents, as well as other valuable information for a particular section of track. The Google Glass interface, which is controlled by voice commands and occasional taps to the side of the glass frame, allows the inspector to visually observe the track continuously while the reference FRA geometry data is viewable in the upper corner of the visual field. If track defects are found, Google Glass allows the inspector to verbally record the findings, automatically tag the GPS location, complete an electronic report form, take photographs and video clips of the rail section, associate that data with a specific section of track, then send the information to a database - all while the inspector is continuously observing the track en route or executing detailed visual inspection and physical measurement procedures on the ground.

This technology provides an innovative way to seamlessly connect individuals with relevant data and information in real time. Due to its unique human-computer interface, Google Glass significantly improves the efficiency of this safety-critical task of railroad track inspection. If this project is successful, Fulcrum believes that most track inspectors will use Goggle Glass, or one of the several other emerging competing optical display products, to conduct manual track inspections while riding in a track inspection vehicle or walking the track.

2. Need Assessment

At-speed automatic track inspection technologies, such as the ATGMS, are currently being implemented; but, it will be years before they will be used widely. Meanwhile, most visual track inspections are conducted manually, especially on short line railroads. Track inspectors ride along the rails in a hi-rail vehicle, observing the track for defects, and when they observe a major defect, they disembark to make more detailed inspections on the ground. Google Glass technology could significantly improve track inspector efficiency, reduce inspection distraction errors and make it easier for inspectors to accept new technologies. The intuitive Google Glass interface, which seems to offer an excellent match with track inspection requirements, should overcome longstanding reluctance to adopt new technologies, provided that this new user interface technology is introduced correctly and adequate training is provided.

3. Technical Approach

Google Glass is a wearable computer with an optical, head-mounted display (OHMD). It displays information in a smartphone-like, hands-free format and Google Glass can communicate with the user with natural language voice commands, head gestures, and the use of a touchpad on the side of the Glass frame (Figure 1). The touchpad allows users to control the device by swiping through a timeline-like interface displayed on the screen. Moving a finger backward on the touchpad shows current events, such as weather, and sliding a finger forward on the touchpad shows past events, such as phone calls, photos, circle updates, etc. Google Glass has a camera that has the ability to take photos and record 720p HD video. It utilizes LED illumination, which can be adjusted for the current location.

Because Google Glass has very limited data storage capabilities, Fulcrum designed an overall system architecture that leveraged the power, storage capabilities and accessibility of a web-based data server. This system can communicate with any number of active Google Glasses on the system and provide requested data based on the geolocation of each Glass. Each Glass must affiliate with a mobile hotspot via Wi-Fi or Bluetooth technology in order to access the internet. Once the device is connected to the system, Fulcrum's design enables the Glass to authenticate with the hosted web-server, announce its location, then request and download appropriate data for its interpolated position.

After evaluating many software development platforms, Fulcrum selected Microsoft's .NET C# software to develop the web-based software application and utilized the Eclipse software development kit (SDK) and the Google Glass Google development kit (GDK) to develop the android applications that would be uploaded to the Google Glass.

Google Glass employs a pre-defined set of menus, applications and a "timeline" that serves the user with "cards" that are chronologically based on the user's activities. For this project, Fulcrum disabled most of the menu items and applications by setting the user's profile in: www.google.com/myglass or configuring the Glass itself. Throughout development, Fulcrum dealt with the problems caused by the "automatic" Glass software updates to the firmware that occurred whenever the device was "online." Google Glass is leading-edge technology. Software updates to the Glass cannot currently be turned off, and there were a few software updates that "broke" the system functionality during development. Each time there was a problem associated with a firmware update, both the web-server and Glass application software were modified to accommodate Google's changes.

ENSCO, Inc. provided FRA track geometry data for analysis and displaying on the Google Glass. The data consisted of mile post number, geolocation coordinates, geometry data, and videos. Fulcrum applied tolerances to the data using FRA 49-CFR Part 213, Subparts A-F to simulate track exceptions.

After initial development of the Glass and Web software was completed, Fulcrum demonstrated the system to the FRA. Fulcrum showed how the Glass could connect to a web server, pass along its geolocation and use menus to select ATGMS data, then view still pictures associated with each milepost and foot along a section of a sample track (Figure 2). For the purposes of demonstration, track data was synthesized and exceptions along the track

were generated by evaluating the track ATGMS data as though it were along a different class of track that would require tighter tolerances.

After the first demonstration, Fulcrum was asked to modify the system so it would allow a complete demonstration to be conducted inside a conference room without real-time GPS interaction or access to the internet. To accomplish that task, Fulcrum created an “internal” or “self-contained” Wi-Fi network that enabled the Glass to communicate with the web server via Wi-Fi. The web-based application was modified so it could:

- Allow the user to synthesize geolocations and simulate movement along a track as it is seen through Google Glass.
- Permit the demonstrator to manipulate the system privately on one screen and project the demonstration on another monitor.
- Provide scalable pop-up screens, attain realistic video refresh rates and display a Google Glass monitor on top of the pop-up screen at all times.

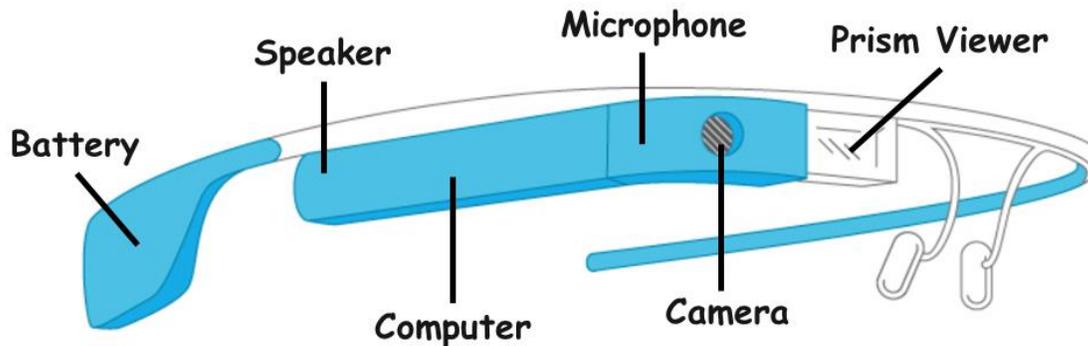


Figure 1. Google Glass Components

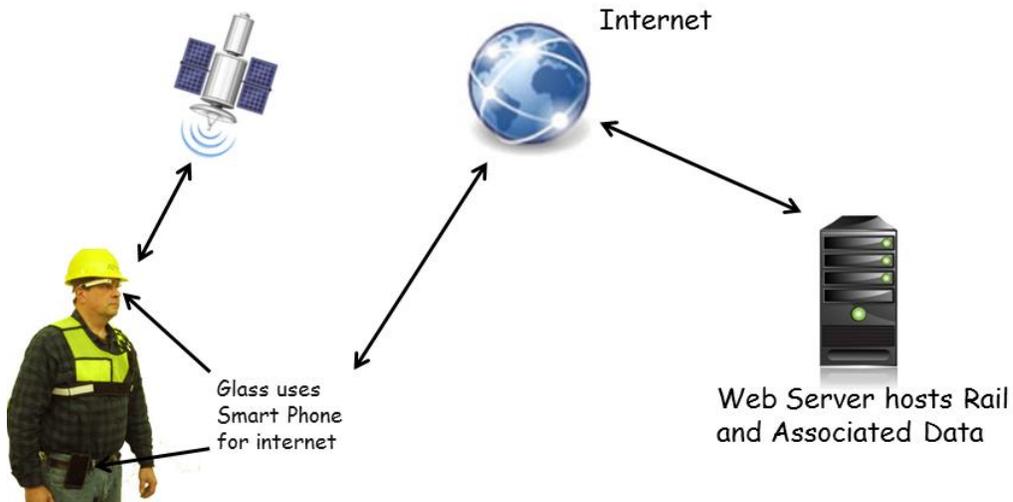


Figure 2. Google Glass Architecture

The following figures (Figure 3 through Figure 8) are various screen captures of the web interface for the demonstrator, what is displayed to the audience, and through the use of the Google Glass Monitor, what the wearer sees through Google Glass prism:

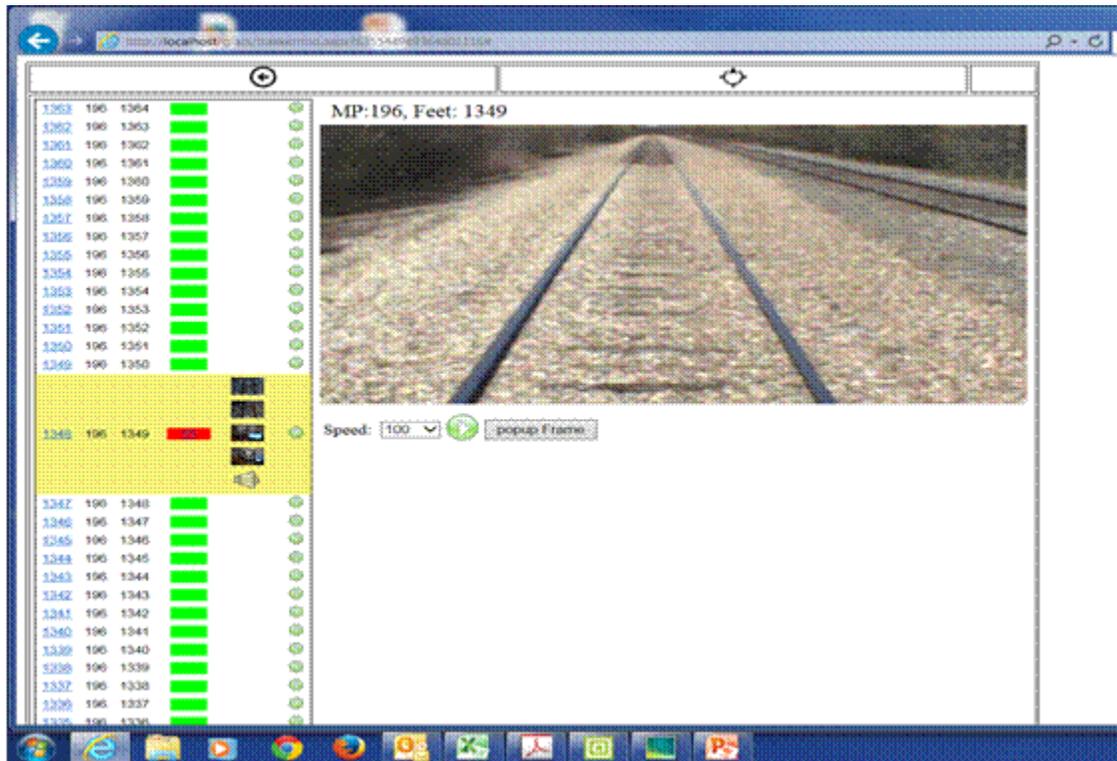


Figure 3. Google Glass Demonstration Interface

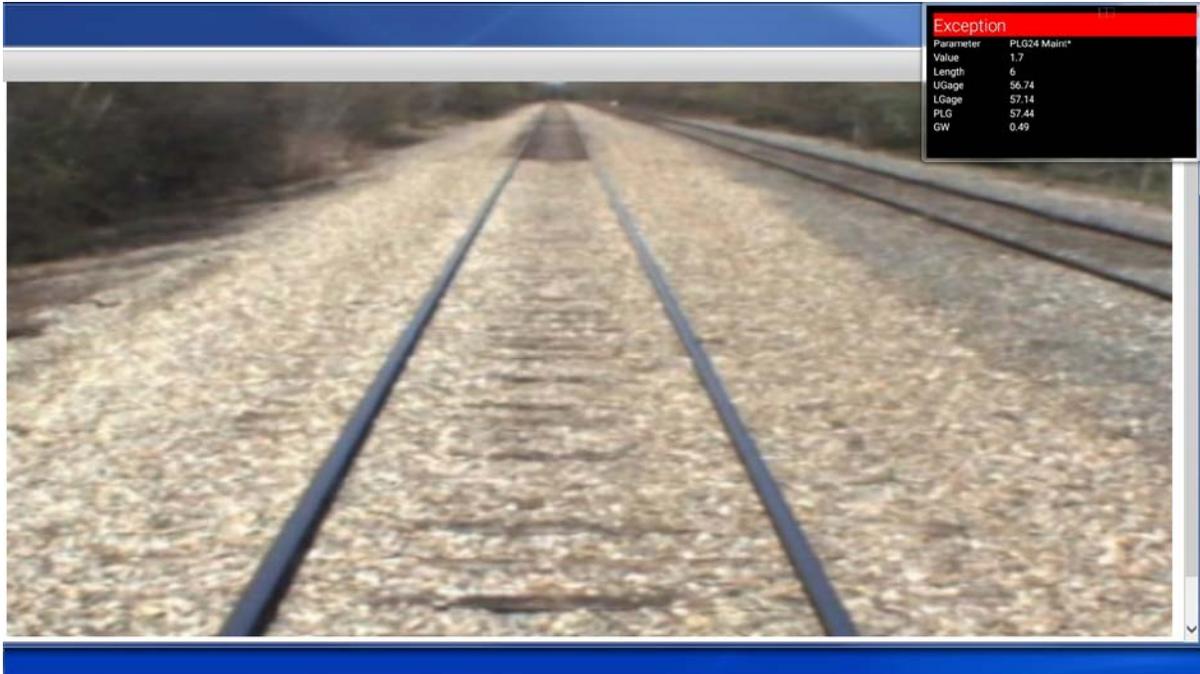


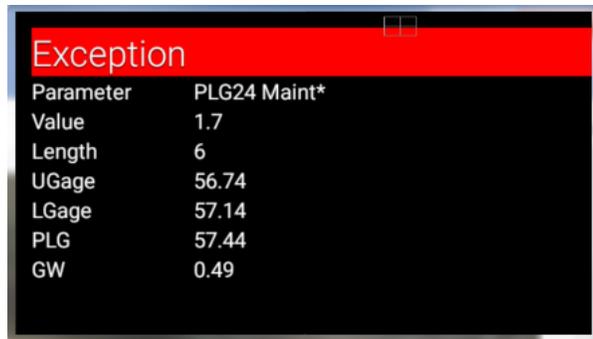
Figure 4. Google Glass Audience Display



Figure 5. Google Glass Display on Track Section without Exceptions



Figure 6. Google Glass Display on Track Section with Exceptions



Exception	
Parameter	PLG24 Maint*
Value	1.7
Length	6
UGage	56.74
LGage	57.14
PLG	57.44
GW	0.49

Figure 7. Google Glass Display of Exception Data

These menus are available to user in Google Glass:

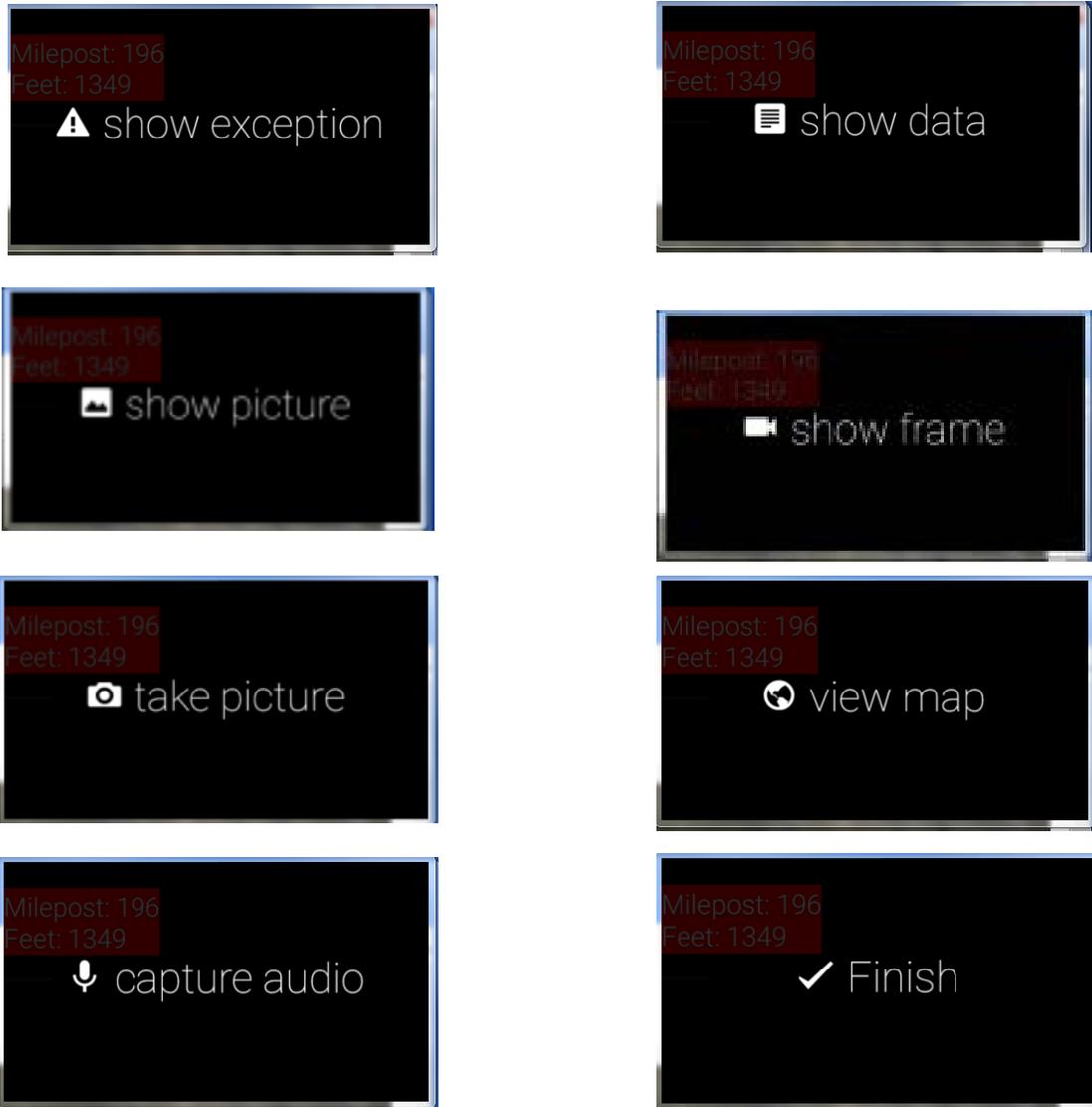


Figure 8. Google Glass Main Menu Choices

When the user requests “show data” the track data is displayed in the following format (Figure 9):



Figure 9. Display of Track Data

When the user wants to make comments, a request is made using the following menu (Figure 10);

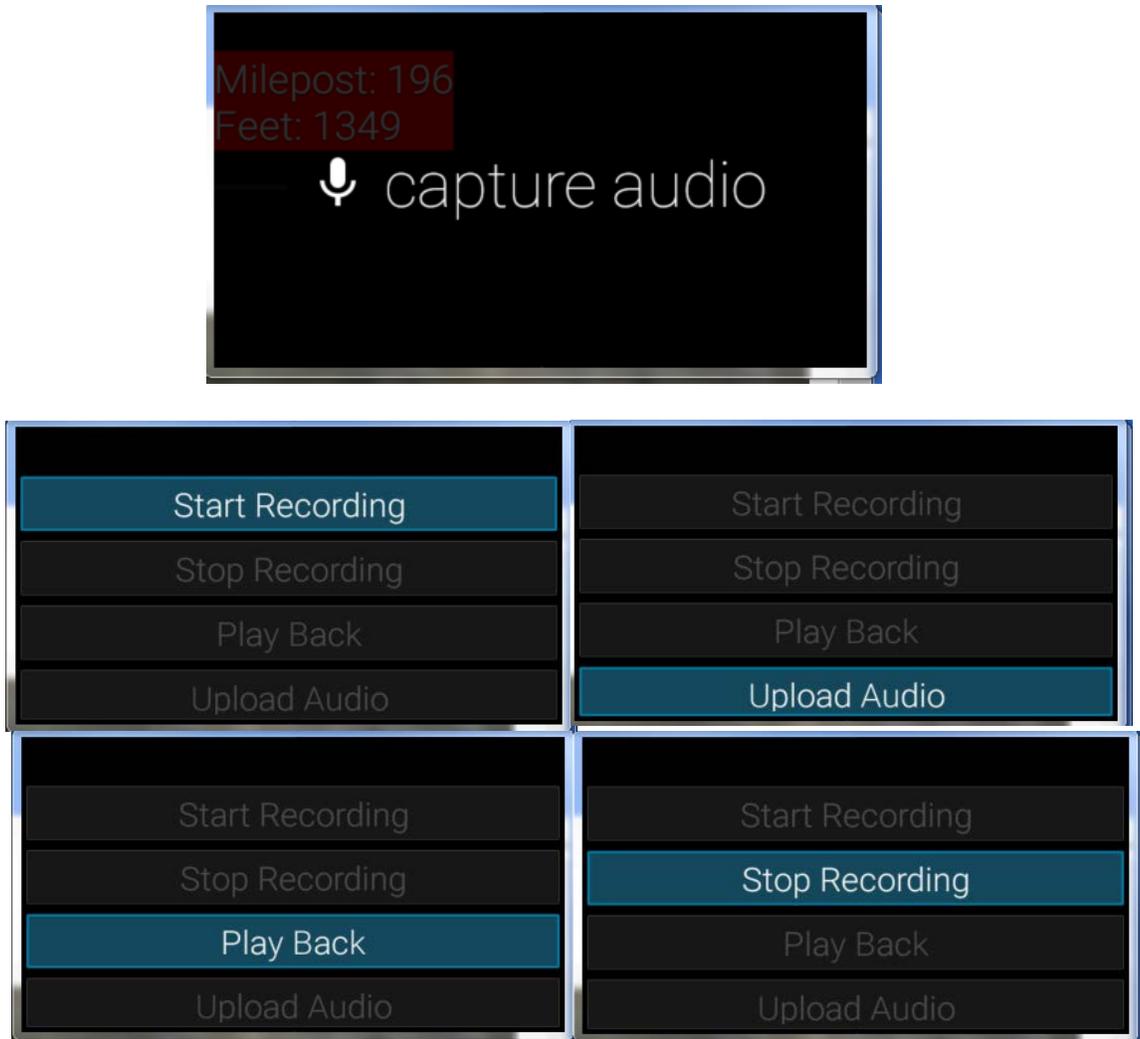


Figure 10. Google Glass Display of Audio Capture Options

When a user request pictures from historical data, the following menu is displayed (Figure 11):

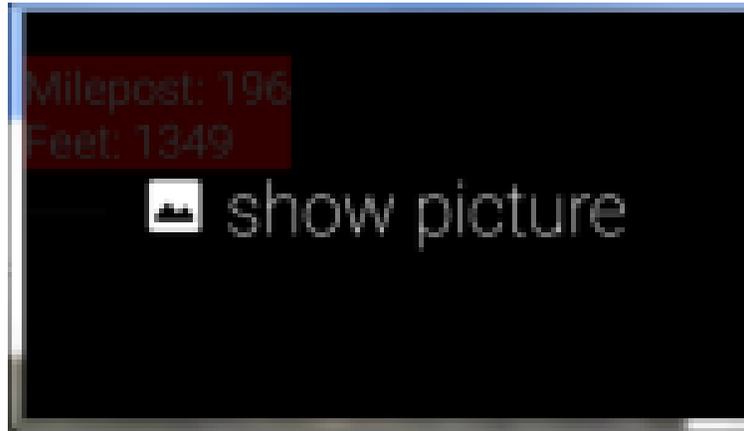


Figure 11. Google Glass Display of Picture Viewing Options

4. Conclusions

Fulcrum successfully demonstrated the use of Google Glass technology for railroad track inspection in the laboratory and at FRA HQ. After evaluating a number of software development platforms, Fulcrum selected Microsoft's .NET C# software to develop the web-based software application and utilized the Eclipse software development kit (SDK) and the Google Glass Google development kit (GDK) to develop the android applications that would be uploaded to the Google Glass. The laboratory demonstration used a simulated section of track with simulated data that were subjected to enhanced tolerances to create exceptions (TRL 4). Future work would involve a validation of the interface in a relevant work environment, on actual tracks with experienced track inspectors (TRL 5).

5. Next Steps

For Phase 2, Fulcrum proposes the following tasks:

1. Develop a top-level cognitive task analysis of a number of defect categories to define data requirements and further development of the Google Glass interface to tailor information display, command structures, and real-time reporting procedures for the track inspection task.
2. Devise a preliminary training strategy for an experienced track inspector which explains how Google Glass can be used for track inspection in selected track defect categories.
3. Demonstrate the Google Glass with an experienced inspector on real tracks to test the interface capabilities, including voice activation, voice recording, real-time data, and taking pictures and videos.
4. Develop a test plan to conduct an experimental run with an experienced inspector along a section of track that has staged defects to measure the efficiency and effectiveness of the Google Glass interface as compared to a laptop computer or handwritten notes.
5. Develop an “App” to detect trains and alert the inspector.

6. References

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2. Jibo He, William Choi, Jason S. McCarley, Barbara S. Chaparro, Chun Wang, Texting While Driving Using Google Glass TM: Promising but not Distraction-Free, Department of Psychology, Wichita State University, Wichita, KS, To be published.
3. Google Glass Developers Guide, Glassware are apps and services designed especially for Glass, built with Glass design principles, <https://developers.google.com/glass>
4. Complete list of Google Glassware and Google Glass Apps - an unofficial app store for google glass with more than ➡ 70 applications and growing as of October 27, 2014, [Google Glass Application List | Google Glass Apps](#) .