Michigan Technological University

Characterization of Unpaved Road Condition Through the Use of Remote Sensing

Deliverable 7-A: Plans for Field Deployment of Recommended System for Remote Sensing of Unpaved Road Conditions

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Purpose of this Document

This document describes the plans for field deployment of the unpaved roads data collection platforms and sensor initially described in Deliverables 4-A (the Sensor Selection report) and 5-A (Recommended Remote Sensing Platforms report). Also included will be a new hexacopter platform that has become available since 5-A to provide a wider view of remote sensing platform capabilities. These deployments will provide the larger data set necessary for the next deliverable report, 7-B, "Performance Evaluation of Recommended System for Remote Sensing of Unpaved Road Conditions." Additional data, beyond the initial exploratory data collections from Fall 2012 will also provide an opportunity to further refine the distress detection algorithms and provide more data to demonstrate within the RoadSoft GIS Decision Support System. Procedures are described that help ensure that the necessary ground truth measurements are taken and that the requirements (Deliverable 1-A) are met to sufficiently assess unpaved road condition in a rapid and cost-effective manner. All Deliverables, 1-A through 6-C, have been posted to the project web page at http://www.mtri.org/unpaved/ (see under the "Tasks and Deliverables" sub-page) and directly at http://geodjango.mtri.org/unpaved/tasks/ (scroll to the bottom of the page, under "Deliverables").

Motivation

Data useful for evaluation of the condition of unpaved roads can be collected using aerial platforms and on the ground. Other documents submitted for this project have outlined the sensors and airframes that will be used to collect aerial imagery for processing with the purpose of extraction of unpaved road condition. This document discusses a systematic collection of aerial data using both manned and unmanned aerial platforms as well as the protocols used to collect the ground reference data necessary to verify the results of image processing work and prepare a formal performance evaluation.

Data Collection Campaign

The primary goal of the summer 2013 field deployment's data collection efforts is to obtain a larger set of example images from our airborne platforms of unpaved road surfaces, ranging from newly graded, to surfaces containing large numbers of ruts, corrugations, and potholes. These images will go through our analysis process (described in Part 2 of Deliverable 6-C), and the road segments will be scored automatically using the Unsurfaced Road Condition Index (URCI) rating system as selected in Deliverable 2-A with modifications to help fully assess unpaved road conditions such as improper cross section and drainage. In addition, these same segments will be carefully measured on the ground, manually, and rated. These results will be compared to our automated outputs for accuracy and performance.

Flight Systems

We will collect data using two UASs, the single rotary-wing platform first described in Deliverable 5-A and a 6-rotor system ("hexacopter") now available to the project team (see Figure 1), as well as a manned fixed-wing aircraft (a Cessna 152) with a camera mounted in a modified flight-approved door. Several of the sites will be collected with both a manned and unmanned system, to compare the performance of the systems, which will be documented in the Performance Evaluation report.

Figure 1: A Bergen hexacopter recently acquired by the project team as part of a demonstration of the capabilities of multi-rotor remote control helicopters. *The system is capable of deploying the same Nikon D800 digital camera as sensor as the Bergen Tazer 800 single-rotor platform but is significantly simpler and easier to fly.*

Road Segment Selection Criteria

We will identify a number of road segments with the following characteristics.

- These will be between 100 feet (30.5 m) and 600 feet (182.9 m) long (100 feet is the recommended segment length for assessment of representative segments for the Department of the Army's URCI).
- The set of road segments chosen will span all the distresses that we need to measure, as well as several segments without damage, for comparison. As described in Deliverable 2-

A, these distresses are improper cross section, drainage, corrugations / washboarding, potholes, ruts, and loose aggregate.

- The roads should be generally unobstructed from overhead, and have a minimum number of obstacles present (e.g. powerlines, stop-lights, etc.).
- At least two of the segments will be measured by both a UAS and manned aircraft, and those segments must be clear of overhanging trees.
- The segments shall be capable of being blocked-off during the duration of the collection.
- Each candidate road segment must be surveyed manually, and all distresses located and characterized.
- The road segments will be in relatively rural sparsely-populated or uninhabitated areas not close to airports (>3 miles / 4.8 km away).

Road Marking and Measurement

Once roads with distresses of interest to the team have been identified, a ground truth data collection team will travel to the selected road a day or so before the scheduled data collection to identify distresses and score the road using the methodology described in Deliverable 1-A. These identifications need to be completed as soon as possible before remote sensing flights to ensure the unpaved road segments have not changed significantly.

The ground truth team will divide the selected road into 100 foot segments. Members of the team will then identify the distresses present within the segment, measure and log the distresses on a score sheet and mark the road with marking paint to identify the distress and its measured extent. An extended score sheet is being developed to allow the ground team to detail the locations of the distresses along with their severity to allow a better correlation of distress location and severity with the output from the automated process. The pavement markings will allow a comparison between the distress area and severity values generated by the ground truth team and those output by the automated system to identify and understand the cause of any disagreement between the automated scoring process and the manual scoring process. Notes will also be made on unpaved road aggregate type – whether primarily made of crushed limestone, natural aggregate or a mix of both types of aggregate.

More specifically, the ground truth team will complete the following ground truth:

Road width will be measured and recorded at each end of the segment and every ten feet (3.05 meters) down the length of the road segment to a precision of +/- four inches.

Road Cross Section ("crown") will be measured and recorded at each end of the segment and every ten feet (3.05 meters) down the length of the road segment. Crown measurements will be made at the same locations as the road width measurements.

Potholes will be measured and classified by their diameter and depth. Potholes will be classified and placed in measurement bins based on depth and diameter according to the table below (from Deliverable 1-A, p. 8). The classification will be used to determine the severity of pothole distress within the measured road segment.

Table 1. Measurement bins for pothole classification (Department of the Army, 1995):

Max. Depth	Average Pot Hole Diameter			
	<1 ft (<0.30 m)	**1-2 ft (0.30 -0.61 m)**	**2-3 ft (0.61 - 0.91 m)**	**>3 ft (> 0.91 m)**
<2" (<5.1 cm)	Number of Occurrences	Number of Occurrences	Number of Occurrences	Number of Occurrences
2"-4" (5.1 cm - 10.2 cm)	Number of Occurrences	Number of Occurrences	Number of Occurrences	Number of Occurrences
>4" (>10.2 cm)	Number of Occurrences	Number of Occurrences	Number of Occurrences	Number of Occurrences

Rutted areas will be classified by the depth of the ruts in the measured area as measured from the bottom of the rut to the adjacent road surface. The rutted surface will be classified into three bins: up to 1 inch (2.5cm) deep, 1 to 3 inches (2.5 – 7.6cm) and greater than three inches deep (>7.6cm).

Corrugations ("washboarding") area is measured in area where corrugation is determined to be present. Severity of washboarding will be determined by placing the depth values of the corrugations into three bins: up to 1 inch (2.5cm) deep, 1 to 3 inches (2.5 – 7.6cm) and greater than three inches deep (>7.6cm).

Roadside drainage (ditches) measurements will be made at the shoulder of the road and at the bottom of roadside drainage if possible. If water is present in the ditch, a measurement of water level must be made and its presence in the ditch noted. These measurements will be made every ten feet and measurements will be made at the same locations as the road width and crown measurements.

Loose (float) aggregate berms will be identified by their width, length, depth and location on the road. Presence or absence of float aggregate berms will be measured every ten feet and berms less than ten feet long will not be considered significant. Assessment for presence and measurement of float aggregate will be made at the same locations as the roadside drainage, road width and crown measurements.

Temporary road marking paint in different colors will be used to define the type of distress and mark it measured extent to facilitate identification of distresses measured on the ground and in aerial imagery. The ground truth data collection team will test/validate data collection protocols and make necessary adjustments to the procedures in advance of flight operations.

Equipment Needed

The primary equipment list that will be needed for the field deployment is:

Bergen Tazer 800, with:

Nikon D800
50mm prime lens
Camera Controller

Bergen Hexacopter, with:

Nikon D800
50mm prime lens
Camera Controller

Manned Fixed-winged flight by licensed pilot John Sullivan at the Ann Arbor airport, identified with help of Chuck Boyle, President of the Professional Aerial Photographers Association (PAPA):

Nikon D800
200mm zoom lens
Camera Controller

Ground Support Equipment:

Ground station computer and controls
Power inverter, 800W
Handheld radios
Safety gear/traffic cones (to control rural road traffic during actual flight time)
Spare batteries - various sizes

Sensor Package Configuration

The Nikon D800 digital camera sensor with the team's frame rate controller will be used for both the remote controlled helicopter and manned fixed winged aircraft collects. It has been important to our team to demonstrate how the same capable sensor can be used with both manned and unmanned platforms, as described in the project 's approved work statement. For the remote controlled helicopter collects, a 50mm prime lens will be used. This lens has proven to be sufficient for collecting the necessary data at that altitude (in the range of 25-30m (82.0 to 98.4 feet). This setup will be the same as in previous collects.

A 200mm zoom lens will be used for the manned fixed winged collects. This has changed from the 105mm prime lens originally used last year, since we were not able to collected imagery with an adequate resolution. The camera and lens will be mounted inside the door of a Cessna 152 where the lens points downward. Earlier collects were conducted with the camera being pointed out of the aircraft window at an angle at the road. The door mounted camera will offer a more stable platform and will take imagery closer to nadir.

Flight Coordination

Remote Control Helicopter:

Prior to a remote control helicopter mission, we inspect the flight path for potential obstructions. Weather conditions are important; >5km visibility, light (<19kph) winds, >2000ft ceiling, dry road-surface are needed. Waypoints are programmed into the autopilot to help the operator follow the centerline of the road segment under evaluation, at an altitude of 25m-30m. For manual flight control, a safety observer is placed at the farthest point from the launch site, to report observations to the pilot.

Fixed-Wing:

Standard flight operation protocols are followed. The pilot will fly at the minimum altitude permitted (generally 500 feet above ground level) at a slow but controllable airspeed and maintain contact with air traffic control as necessary for safe operation.

Flight and Collection Operations

A mission plan will be prepared for each road segment, identifying flight waypoints, altitudes, and speeds. For the helicopter, we will operate in GPS mode while collecting imagery, with a safety pilot in control at all times as the mission operator. The hexacopter will be flown in flight-assist mode, with the safety pilot guiding the aircraft along the flight-path, with auto-pilot attitude stabilization. The manned flights will have a ground-crew on-site to control traffic during the overflight.

For safety reasons, the unmanned helicopter systems will only be operated in uninhabited, or sparsely inhabited, areas, with no pedestrian traffic present. Similarly, the fixed-wing aircraft will only be operated along segments where a 500ft altitude can be maintained without danger to persons or property in case of an emergency landing, meeting standard FAA requirements.

There should be as little time as possible between the manual ground truth survey and the overflights, to ensure a consistent road condition. Ideally, this will be the same day, but it may be as many as three days on lightly-traveled roads assuming no weather events.

Data Formats

Data on road condition needs to be obtained in two distinct formats: the "manual assessment" data, consisting of measurements on the ground by trained personnel, and the "automated assessment" analyzed digital imagery outputs generated from the images taken by the sensor package. The manual measurements are considered the "ground truth", against which all the automated outputs are assessed. A standardized form for manual assessment has been created for this purpose.

Proposed Calendar of Events

Data collections will take place during the summer of 2013, depending on weather, safe operations, and conditions of available rural unpaved roads. The project team is currently considering four possible weeks in June, July, and August for data collections. These are currently intended for:

June 17-21
July 8-12
July 15-19
August 5-9

Concluding Comments

This Deliverable report has described the field deployments plans necessary to collect sufficient data for the project's upcoming Performance Evaluation report (Deliverable 7-B), to help complete any refinement of analysis algorithms, and to demonstrate the integration of additional analyzed data within RoadSoft GIS. Deliverable 7-B is now due by the end of month 26 of the project (end of September, 2013, as described in the project's recent no-cost time extension. These data and evaluation will also help with demonstrating the utility of the platforms and sensor as part of the extended outreach approved as part of the project extension.