Calibration of 3D Scanners for the Autonomous Monitoring of Paved Surfaces

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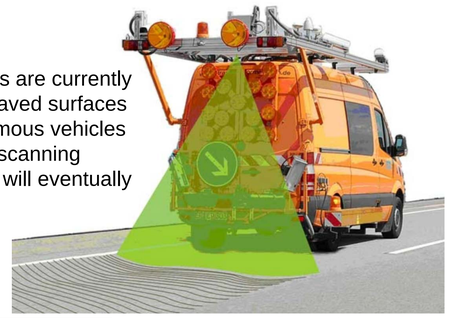
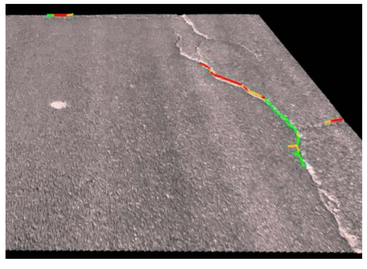
Abstract

Aging American roadways are quickly deteriorating. Monitoring over 2.6 million miles of pavement is an extremely resource-intensive process jointly because of the lack of automation and because of the sheer scope of the task. As a result, repairs are often put off until the roads are critically damaged to ease the strain on workers.

This research will provide valuable information regarding the deployment of several remote, self-sufficient robots which would allow paved surfaces to be monitored much more frequently, allowing repair crews to begin addressing the minor, inexpensive repairs as well as the larger, more expensive ones.

3D scanner-equipped cars are currently the only way to monitor paved surfaces for damage. With autonomous vehicles and improvements in 3D scanning technology, maintenance will eventually become fully automated





Picture by Brenda Rector, Faculty Member, Transportation and Logistics Management at American Public University

Road wear identified by 3D scanning

Methods

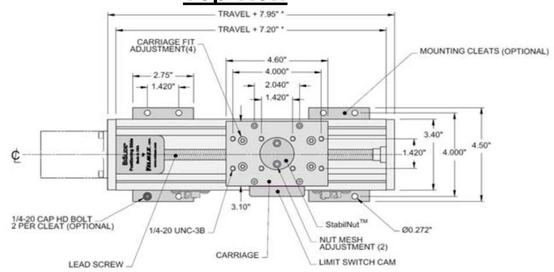
The goal of this research is to develop MATLAB code to command a 3D scanner into multiple positions across its range of motion in order to calibrate the device.

The automation of the scanning process depends on the ability of robots equipped with 3D scanners to follow preset paths as well as the proper calibration of the 3D scanners themselves. To calibrate these devices, serial communication can be used to relay commands to a stepper motor-driven cross slide assembly. The calibration of the device's camera relies on its ability to travel to preset points, in this case input into the code as coordinates.

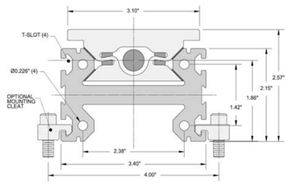
Experimental Design

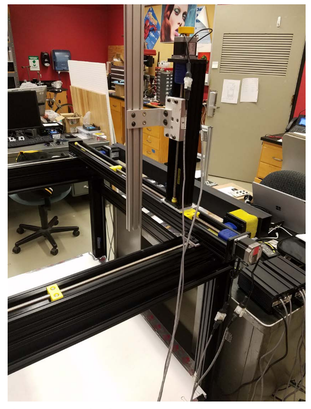
The assembly consists of 3 Velmex BiSlide rails with xyz dimensions 4' x 6' x 2' respectively, each BiSlide rail has the dimensions shown below, with the only variance being the total length of the unit.

Top View

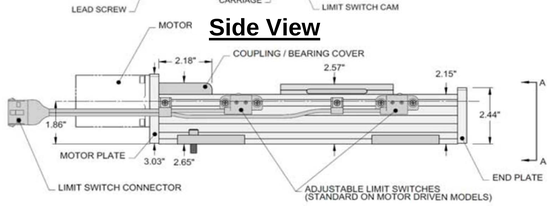


Cross Section





Side View

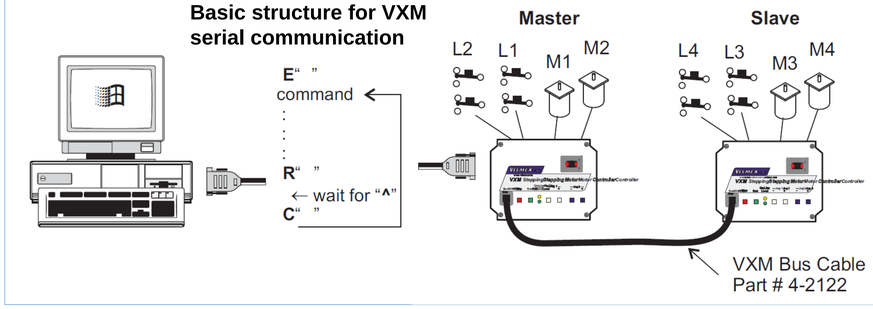


Given the torque-speed curve of the PK266 motor, the weight of the carriage assembly, and the specifications of the E04 lead screw, the scanner will have a maximum travel speed of around 6 inches per second:

$$\frac{0.4\ inches}{1\ turn} \cdot \frac{1\ turn}{400\ steps} \cdot \frac{6000\ steps}{1\ second} = 6\ \frac{inches}{second}$$

The size of our machine makes zeroing the carriage after each input tedious. To eliminate unnecessary movements, the machine should be able to move directly from one point to the next after the initial zero is located. This means that the code must be able to determine the (signed) number of steps along each axis between the current location and inputted point.

Basic structure for VXM serial communication

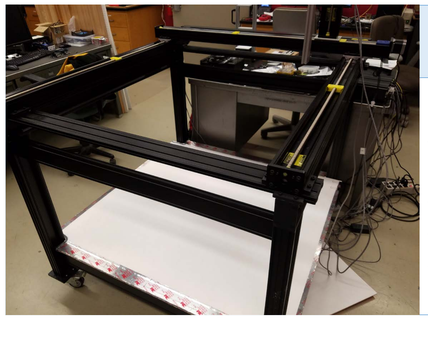


Code Features

- Automatically clears current program from VXM memory
- Establishes one VXM as master, one as slave
- Only requires zero on startup
- Easily converts between inches/centimeters/steps
- Allows carriage movement with ±0.0005" precision

Results

```
%% Connecting

% Find a serial port object
obj1 = instrfind('Type', 'serial', 'Port', 'COM4', 'Tag', '');

% Create the serial port object if it does not exist
if isempty(obj1)
    obj1 = serial('COM4');
else
    fclose(obj1);
    obj1 = obj1(1);
end

% Connect to instrument
fopen(obj1);
%sobj1.Terminator = 'CR';

%% Control
%% Set-up
fprintf(obj1, 'K');
fprintf(obj1, 'C');
fprintf(obj1, 'F I1M-0, I2M-0, I3M-0, P10, R');
fprintf(obj1, 'C, N, R');


%% Moving Moters
while( 1==1)
    userx = input('place to move to x axis to move in inches: ');
    usery = input('place to move to y axis to move in inches: ');
    userz = input('place to move to z axis to move in inches: ');

    output = strcat('C ', strcat('IA1M', int2str(userx*1000)), ', ', strcat('IA2M', ...
        int2str(usery*1000)), ', ', strcat('IA3M', int2str(userz*1000)) , ', R');
    fprintf(obj1, output);

end

%% Disconnect and Clean Up

% Disconnect
fclose(obj1);

% Clean up
delete(obj1);
clear obj1;
```



Conclusion

Ultimately, a reliable method for calibration was developed for portable 3D scanners. These scanners are intended to be combined with autonomous vehicles to allow for the monitoring of roadways and other paved surfaces without any human involvement. Airport runways, for example, could be checked daily by small, self-driving vehicles deployed during the off hours. This would ensure that minor repairs are identified and mended before they develop into larger, more expensive ones.