MDOT 3D Bridge App – The Digital Future Of Bridge Inspections

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The Problem

- Faced with an aging bridge inventory and increasing federal regulations for collecting element level data, MDOT wishes to increase the efficiency and reliability of collected data.
The Problem

- Current bridge inspection practices at MDOT utilize paper forms followed by a manual data entry step to populate their database.
Additionally, photographs documenting bridge deterioration are collected and stored separately from inspection data.
MDOT inspectors must also carry reference manuals and past inspection reports to help verify the accuracy of the data they are collecting.
The Problem

- The exact locations of bridge defects are not stored which creates an inconvenience as the data are difficult to visualize, to tabulate overall defect quantities, & to duplicate inspections.

- Federal regulations now require inspectors to collect AASHTO Element level data. Current processes don’t enable the efficient collection of this data.
The goal is to help MDOT take advantage of the advances in portable data entry technologies, reduce the time needed for field staff to collect bridge inspection data and thereby help have a safer bridge inspection program, and help provide a compatible path forward to a more efficient bridge inspection process that is available to all appropriate levels of MDOT.
Objectives of MDOT Wireless Study

- Develop a wireless web/tablet based bridge inspection data collection system. This system would:
  - Use 3D models to help collect data.
  - Integrate with MDOT Michigan Bridge Reporting System and other current MDOT bridge inspection processes.
A tablet application for MDOT Bridge Inspectors for the collection, display, and summarizing of Bridge Inspection Data.

Leverages the latest in game development technology: Unreal Engine 4

- Provides cross platform compatibility on everything from Windows Desktops to Android/iOS phones or tablets.
The 3D BRIDGE app helps MDOT take advantage of the advances in portable data entry technologies, reduce the need for field staff time to collect bridge inspection, and facilitate the bridge inspection process.
How will this tool work from the Bridge Inspector's point of view?
With no previous 3D models of the bridges available, a model had to be created from scratch.

Large amounts of descriptive information within MDOT's Bridge Management Database.
The 3D BRIDGE App Grabs Data from BMS Database

- Queries all of the data from a static copy of MDOT’s database.
  - Static copy recent as of October 2018

- The MDOT bridge management database is composed of 16 tables.

- The 3D BRIDGE App queries from almost all of them.
User Tuning

- Created a user interface for fine tuning the 3D Bridge model
- Missing data is filled in with generic assumptions.
- User can alter data to fix any assumptions that were mistakes.
- <Member>
  <role>Deck</role>
  <type>Concrete Deck - Coated Bars</type>
  <name>2S</name>
  <length>1451.98234368</length>
  <width>491.47385216</width>
  <height>15.0</height>
  <AASHTO_Element_803>803</AASHTO_Element_803>
  <x>1229.9850432</x>
  <y>265.73692608</y>
  <z>270.5133888</z>
Select Bridge from Queue. Server queries database, generates Bridge Model XML Document, and passes to Server.

XML’s can be saved locally so WiFi/Cell access is not required in the field.
Desired bridge loads and is rendered

Application Renders Bridge Model in 3D – Inspector can navigate to Inspection Views
Navigation is constrained to an orbit around the bridge

“Cylinder View” ensures you will always have a useful view of the bridge.

Touching any location on the Bridge Model will indicate a location for any defects associated with that element type (eg concrete deck)
The 3D BRIDGE App enables bridge inspectors to collect and record all of the necessary data for the bridge inspection process in one tool.

Each individual defect can be annotated with a description, photos, and quantity.

Inspectors no longer have to carry the Bridge Element Inspection Manual.

Context-sensitive descriptions are attached to each element type, just as in the "Bridge Element Inspection Manual".

Fields will be pre-populated with the db values from most recent inspection in future.
Defects can be tagged with photos. Clicking on a photo thumbnail brings up a fullscreen view.
Customize the Defect’s Size and Shape

Aspect ratio allows you to switch between circular and rectangular defects.

Slider bars make adjustments easier on a tablet than using the virtual keyboard.

Rotate and Reposition to get your marker in the exact right spot.
Copy/Paste Defects

Copy/Paste defects onto the same element type

Will be developed into the ability to place defects on regular intervals: eg “vertical cracks every 10ft on railing”
Automatic Clipping

Defects are limited to the element they are attached to, and cannot extend beyond that to ensure accuracy of total quantity.
Colors indicate condition states, and relative sizes are proportional to "quantity"
Saves the Defect’s 3D Position For Future Inspections

Compass lets you switch view directions. Eye icon lets you switch between orbit and along bridge views.
Pinch to zoom in on a part of the bridge, or a defect.
Write on the scratch pad to add any additional comments or drawings

Large Spall on Span 2w
Review NBI Report Information in the “NBI Report” Summary Tab, and expand the report according to the category.
Collect and Display NBI Information

- Enter in NBI Information by clicking the “NBI Ratings” button. Use previous comments from past NBI Reports using the “Download” arrow button.
Enter in the NBI Rating for a category by using user-friendly NBI Rating wheel
Collect and Display NBI Information

- Scroll through the entire report, and review NBI ratings of past and current reports.
Display and summarize the bridge inspection data with different views.

AASHTO
Element Level
Data View
Partial Transparency allows inspectors to see what they have placed on either side of a component.

Full Transparency hides defects too, letting inspectors zero in on locations that may otherwise be hidden by other components.
For components such as this abutment, only the linear projection of the defects counts, the applications performs this calculation automatically.

When the defects overlap, the defect with the highest severity rating takes precedence.
Components with area quantities still have to deal with overlap, such as defects on the top and bottom of the bridge deck. The application also handles this computation automatically.
These calculations are reflected in the summary report. Here the fair defect partially overlapped the poor defect, both defects are reported but only half the fair defect counts towards the total quantity for the abutment.
**Save/Load**

- User’s can save the progress of their inspection on their mobile device using named save files.
- Application also autosaves their progress every time they make an update, so they can restore should their work be interrupted unexpectedly.
Save/Load

Load menu gives a list of all save slots, selecting a save slot will list the bridge id, location, and date the save was created.

- Can also delete unneeded/old saves
It was necessary to develop a system to import/export data from the MDOT Bridge Management Database.

All relevant data can be saved in an XML file for later upload to the database management system. While not as convenient as a direct uplink, it is also independent from MDOT’s database (could be readily adapted to work with other database systems, as the bridge app does not need to change).
XML cont’d

- XML contains the data needed to build the bridge model, previous NBI data, and current NBI ratings and bridge defects.
  - Does not currently contain photos, but all other defect information is stored
    - Photos are still on the tablet device and could be uploaded with whatever method is currently in place to deal with inspection photos.

- Exported XML files can be imported back into the app on any device.
  - Behaves like a save file, restoring the inspection to the state it was at when exported.
The Application is Cross-Platform

- The 3D BRIDGE App is compatible with Windows and Android, and iOS.
Where We Are At Now

- Currently development is focused on meeting a few remaining key priorities of MDOT
  - Handling bridge skew in model generation
  - Adding additional model components
  - “Draw On Defects”, inspectors can draw a defect onto the surface
  - Automatic conversion to gridded format
    - Useful as input to deterioration modeling
  - We also have a whole list of suggestions from inspectors that we will tackle as we have time

- We are starting a limited testing this spring
  - Select inspectors will have access to the early app version to provide feedback
    - Critical to ensure application success, we want this app to work!

- Project goes to March 2020
  - ready-to-use tool through this year’s 2019 testing & updates
Benefits

- Benefits of using a location-specific 3D interface extend beyond inspection, but also a tool for future asset management
  - 3D BRIDGE App enables this future
    - Rich with research opportunities, such as integration of remote sensing data, improved bridge model representations, etc.

- Enables transportation agency users (MDOT, etc.) to tie condition and deterioration of one component to related components

- Improves forecasting of condition, bridge needs
  - Leads to better, more efficient asset management
3D BRIDGE app is a key component towards the future goal of utilizing 3D models to monitor and review a bridge throughout its lifetime.
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