3D BRIDGE app overview: Enabling the Future of Bridge Inspection Data Collection

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The Problem

- Faced with an aging bridge inventory and increasing federal requirements for collecting element level data, MDOT wished to increase the efficiency and reliability of collected data.
Current bridge inspection practices at the Michigan Department of Transportation (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 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 tabulates overall defect quantities, & to duplicate inspections.

- Federal rules require inspectors to collect AASHTO Element level data. Current processes don’t enable the efficient collection of this data, especially for recording location-specific information.
Objectives of MDOT Wireless Bridge Inspection Study

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/tables 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.
MDOT’s requested solution

- A **tablet** application for MDOT Bridge Inspectors for the collection, display, and summarizing of bridge inspection data.
The 3D B³RIDGE app

The 3D B³RIDGE 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?
Overview videos available

Introduction to the 3D BRIDGE App for bridge inspections

https://www.youtube.com/watch?v=sCrxqZ57aol

http://www.mtri.org/3dbridge.html
With few 3D models of the bridges available, a model needed to be created from scratch

- Wanted to be able to use a 3D model for a bridge needing inspection, regardless of whether one already existed

- Large amounts of descriptive information within MDOT's Bridge Management Database
  - Sufficient information to auto-generate a sufficiently representative model of most bridges needing inspection
The 3D B^RIDGE App Grabs Data from BMS Database

- Queries all of the data from a static copy of MDOT’s database.
- The MDOT bridge management database is composed of 16 tables.
- The 3D B^RIDGE App queries from almost all of them.
User Tuning

- Created a web-based user interface for fine tuning the 3D bridge model
- Missing data are filled in with generic assumptions.
  - Ex: locations of pin & hanger assemblies
- User can alter data to fix any assumptions that were not correct
Outputs bridge XML to create model.
  - Small file transmitted to tablet to create 3D model on the fly

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      <role>Deck</role>
      <type>Concrete Deck - Coated Bars</type>
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      <height>15.0</height>
      <AASHTO_Element_803>803</AASHTO_Element_803>
      <x>1229.9850432</x>
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      <z>270.5133888</z>
  </Member>
```
Select bridge by Region / StructureID

Select Bridge from Queue. Server queries database, generates Bridge Model XML Document, and passes to Server.

Many was restricted to a view of example bridges. A more comprehensive list can be added as well as search features and user-defined short lists.

3D model is auto-generated using Epic Games’ Unreal Engine, also provides user interface.
Desired bridge loads and is rendered

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Application Renders Bridge Model in 3D – Inspector can navigate to Inspection Views

Additional menu functions have been added, such as save/load

Navigation aids such as directional notation (eg slab 1N) can be added
Navigation is constrained to an orbit around the bridge

“Cylinder View” ensures you will always have a useful view of the bridge. An additional along-bridge view is planned to offer perspectives common in the inspection process.

Touching any location on the Bridge Model will indicate a location for any defects associated with that element type (e.g., 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.
View Photos of the Desired Defect

Defects can be tagged with photos. Clicking on a photo thumbnail brings up a fullscreen view.
Customize the Defect’s Size and Shape

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

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

Rotate and Reposition to get your marker in the exact right spot.
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

- 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
View Different Summaries of the Recorded Data

- Display and summarize the bridge inspection data with different views.

**Bridge Review**

**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, only the most serious counts.
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.
Users 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
XML Import/Export

- It was necessary to develop a system to import/export data from the MDOT Bridge Management Database.
  - Would like to replace this with direct write to BrM 5.2.3 as its implemented by MDOT, with appropriate review

- 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.
  - Unreal Engine platform is cross-platform compatible
Benefits of using a location-specific 3D interface extend beyond inspection, but also a tool for future asset management
  - 3D B\textsuperscript{RIDGE} App enables this future

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
The Future of Bridge Inspections

- 3D BRIDGE app is a key component towards the future goal of utilizing 3D models to monitor and review a bridge throughout its lifetime.

Next steps:
- MDOT: full implementation after BrM 5.2.3 deployment & integration, expand to more bridge types, user enhancements
- Integrate other distress data (from NDT / remote sensing / UAV platforms / other sources)
- Other states: Interest in version for other states
- National: could be a national tool; interested in AASHTOWare BrM integration; complex / big bridge application
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