Road inventory database system using road image and geo-coordinates

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Quality Infrastructure – Japanese Road Condition

• Road Network
  – Critical infrastructure for dynamic economic activities
  – Deterioration; increase the risk of accidents, disturb traffic

• Good-Quality - Japanese Road Network
  – Expressway; 9,000km
  – National Highway; 67,000km
  – Prefectural Road; 142,000km
  – Municipal Road; 1,055,000km

• Road Asset Management (from 1970’s)
  – Data Collection
  – Monitoring
  – Examination
  – Assessment
  – Evaluation
  – Repair Construction
Deterioration of Infrastructure (Road)

- Common deterioration of road in Japan

and a fatal accident

- Tunnel collapse accident
  - Dec-2012
  - Sasago Tunnel
  - 9 casualties
Challenging in Rural road management

Road Length

- Community Road: 81%
- Arterial Road (Provincial): 16%
- Major Arterial Road (National Highway): 3%

Pav. repair cost (30 years)

- Community Road: 40%
- Arterial Road (Provincial): 38%
- Major Arterial Road (National Highway): 22%

Graph showing the pavement repair cost over 30 years for different types of roads.
Deterioration of Infrastructure (Road) in Ethiopia
Data Quality and Quantity for Road Management

Data Quality

Stage – 1
Un-completed
Small data

Maintenance

Stage – 2
Completed
Small data

Stage – 3
Big Data

Stage – 4
Asset Management

Intellectual Technology (Software)

Hardware Technology

Inspection Systems

Visual Inspection

Sensors, Non-destructive examination (ex. FWD)

Data Quantity

Maintenance ≠ Management

Management System

RISK (%)

repair cost (million VND)
elapsed year

OL replacement risk
Primary Purpose of Asset Management

Optimum Repair/Rehabilitation Policy which can minimize Life Cycle Cost

- LCC Costs & Investment Timings.
- Cost Proven Repair/Rehab., DB
- Investment Timing Deterioration Process
Markov Transition Probability

\[ \pi_{ij}(z) = \text{Prob}[h(\tau_B) = j | h(\tau_A) = i] \]

\[
= \sum_{m=i}^{j} \prod_{s=i}^{m-1} \frac{\lambda_s}{\lambda_s - \lambda_m} \prod_{s=m}^{j-1} \frac{\lambda_s}{\lambda_{s+1} - \lambda_m} \exp(-\lambda mz)
\]

(i = 1, \cdots, I - 1; j = i + 1, \cdots, I)

\[
\left\{ \begin{align*}
\prod_{s=i}^{m-1} \frac{\lambda_s}{\lambda_s - \lambda_m} &= 1 \quad (m = i) \\
\prod_{s=m}^{j-1} \frac{\lambda_s}{\lambda_{s+1} - \lambda_m} &= 1 \quad (m = j)
\end{align*} \right.
\]

\[ \lambda_s : \text{Hazard Rate from rating s to s+1} \]
Pavement maintenance work and data management

Pavement Maintenance work flow

1. Asset context
2. Survey/Inspection
3. Repair/Rehabilitation

Database

- Inventory
- Inspection data
- Maintenance data

System

Analysis/Evaluation

Only the data used in daily maintenance work is used as input data

-> without requiring additional data collection for the system
PDCA Cycle and Management Governance

**Maintenance Cycle**
- Plan (C&A)
- Data accumulate for monitoring

**Management Cycle**
- Monitor & Evaluate PDCA Cycle
  - Policy target (output, outcome) analysis
  - Review Logic Model
  - Review input

- New policy for system improvement

**Management of Maintenance Cycle**
(Budget use)
Deterioration Prediction and Performance Evaluation

**Deterioration Prediction**

- Physical model (theoretical model)
  - Pavement deterioration prediction based on deterioration mechanism of structure types and materials

- Statistical Model
  - Ex-post evaluation of deterioration performance using information of actual deterioration performance

**Deterioration Performance Evaluation**

- Pre-set basic model (deterioration curve)
  - We attempt to minimise the "mistake"

- Past deterioration performance evaluated using collected data on site (inspection and maintenance history)

- Maintenance ≠ Management
Bench-marking evaluation and LCC assessment

- Long-life pavement and LCC assessment strategy based on deterioration performance evaluation

![Performance Curve (IRI) of NHs in RMB I](image)

- Unusual route
- Average life length (As-Is)
- Extended life expectancy
- Improved life length (To-Be)
System Overview (Basic Picture)

- Road Asset Management DB System
  - to support road maintenance work

  Road Inventory DB
  To see all road asset data, inventory, condition

  GIS Map
  To see the location of each road facility

  Road Image
  To see landscape of surround the road
Concept - Road inventory database system

• Simplified data collection system
  – For sustainable implementation for all users

• Platform inventory database with Road Image Data
  – Road Image Data with Geo-coordinates and GIS

• Support input and update pavement database
  – Easy find the location of road segments on the road without kilo-post station

• Platform database system
  – Accumulate time series data of pavement maintenance
Service contents

**Simplified & low-cost data collection**
- GPS
- Camera

**Mobile System**
- GPS

**Road Inventory Database**
- Digital map
- Aerial Photo

**Management System**

**Decision-maker**

**Site-engineer**
The system is the compact measurement system which CCD camera and GPS are attached.

Several choices are available for the quality and the number of the camera.

Front images can be acquired by same interval. The interval can be changed as one chooses.

### Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>GigE Vision Interface</td>
</tr>
<tr>
<td>Note PC</td>
<td>Windows OS</td>
</tr>
<tr>
<td>Control box</td>
<td>System control (IME0805)</td>
</tr>
<tr>
<td>Inverter</td>
<td>400W, 50Hz/60Hz</td>
</tr>
<tr>
<td>GNSS Receiver</td>
<td>M-215+</td>
</tr>
<tr>
<td>Adapter</td>
<td>Cigarette socket adaptor</td>
</tr>
</tbody>
</table>
Basic Technology - Data Collection -

Front View Image

- Front images are acquired by same interval (time, distance)
- Each image has GPS coordinate (longitude, latitude)
- No limitation to vehicle speed (No minimum speed for the system)
- After Data Collection, operators work on Data Processing
Road line colors indicate road condition.

Pavement: contents

Route information
Pavement condition
Repair history
Front view image
**Basic Technology - Data Management -**

- Grasp the position of the inventory at a glance on GIS map
- Click the item to check the current images

**Inventory**

Select the inventory which you want to check

*Example: Traffic signal*
Data Processing

- Make item columns
  (simple ver: Pavement, Slope, Drainage, Bridge
   full ver: Pavement, Slope, Drainage, Bridge, Signage, Sidewalk)
- Erect a item flag when it comes inside green grid area (inside red line)
- You should erect item flags with your own lane (do not care about the opposite lane)
Evaluate the condition of pavement inside the green grid area by 3 ranks

- Rank 0: stable
- Rank 1: needs routine repair (cracks, shallow rutting)
- Rank 2: needs emergency repair (Pothole, Deep rutting, deep damage)
- Rank 9: Unpaved

*You can decide by impression and when you become unsure which rank is correct, you should choose worse one
* You should evaluate only traffic zone where you are traveling
Slope (rank 1)

◆ Evaluate the condition of slope inside the area
  ◆ Rank 0: no slope
  ◆ Rank 1: unreinforced slope surface exists inside the area
  ◆ Rank 2: reinforced slope surface exists inside the area (mainly covered by concrete)
  ◆ Rank 3: unreinforced slope surface is collapsed inside the area
  ◆ Rank 4: reinforced slope surface is collapsed inside the area
Evaluate the condition of Drainage inside the area

- Rank 0: no Drainage
- Rank 1: Drainage canal exists inside the area
- Rank 2: Drainage hole (besides canal) exists inside the area
- Rank 3: Drainage hole is clogged by the waste materials (such as soil or reaves) or broken
◆ Evaluate **the condition of slope** inside the area

◆ Rank 0 : no slope
◆ Rank 1 : unreinforced slope surface exists inside the area
◆ Rank 2 : reinforced slope surface exists inside the area (mainly covered by concrete)
◆ Rank 3 : unreinforced slope surface is collapsed inside the area
◆ Rank 4 : reinforced slope surface is collapsed inside the area
◆ Evaluate **the condition of Bridge** inside the area

◆ Rank 0: no Bridge

◆ Rank 1: Bridge exists inside the area

◆ Rank 2: Bridge has some points to be repaired
◆ Erect the Sidewalk Flag if it is inside the area
  ◆ Rank 0 : no Sidewalk
  ◆ Rank 1 : Sidewalk exists inside the area
Erect the Crossing Flag if it is inside the area

- Rank 0: no Crossing
- Rank 1: Crossing (with no traffic signal) exists inside the area
- Rank 2: Crossing (with traffic signal) exists inside the area
◆ Erect the Shoulder Flag if it is inside the area
  ◆ Rank 0 : not
  ◆ Rank 1 : exist
Road Maintenance – Routine Maintenance

Input inspection result

Accumulation of inspection result accurately is necessary to make reliable road maintenance work

- Find inspection location, target facility on the system and input inspection result on the system
- Using mobile inspection system, location can be set by GPS and send data to the DB (automatically)

Request from citizen, plan from the sub district level can be inputted using the same procedure.
Road Maintenance – Road Asset Management

Data update, input

Data update, input to keep data reliability is important for road asset management and reliable road maintenance plan

- Support to input repair history data easily
- Find construction location, target facility on the system
Road Maintenance – Routine Maintenance

**Screening survey for inspection**

- Screening survey using road image in office makes it possible to find the focused section which has high damage and to make inspection work efficient by making a prioritization for inspection work.

<table>
<thead>
<tr>
<th>AS - IS</th>
<th>TO - BE</th>
</tr>
</thead>
</table>
| **Visual Inspection**  
Subjective evaluation  
For all road sections | **Screening survey using road image**  
Objective evaluation for all road sections in office to make a prioritization for inspection  
**Visual Inspection**  
Focus on high damaged section |
Road Maintenance – Routine Maintenance

*Screening survey for inspection*

Ex. Flow from Road inspection through Maintenance Plan

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Method/Tool</th>
<th>Data Collected</th>
<th>System Linkage</th>
<th>System Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduled Inspection (Road image data collection)</td>
<td>By Pavement Condition Survey Vehicle</td>
<td>Road Visual Image And IRI (All Targeted Road)</td>
<td>Input to the system (IRI, Visual Image)</td>
<td>Caution needed Areas (requiring Visual Inspection) are outputted</td>
</tr>
<tr>
<td>Visual Inspection</td>
<td>1) Judge on Visual Image</td>
<td>Surface Damage (Crack, Pothole Ratting and so on)</td>
<td>Input to the system (Damage Information)</td>
<td>List of prospective Areas requiring repair works is outputted</td>
</tr>
<tr>
<td></td>
<td>2) Visual Inspection (Mobile Inspection System)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Road Maintenance – Periodical Maintenance

Prepare annual road maintenance plan

- Prepare annual maintenance plan based on actual data (inventory, inspection, repair history information)
- Make prioritization according to road damage level and road inventory

**Condition data**
- Repair method
- Repair cost
- Budget constraint
- Repair criteria
- Prioritization

**Inspection data** (damage level)

**Road Inventory** (Road width, Road Status, Public facility, Traffic volume and Special area)

List of section, facility to be repaired

Location Map

Annual Maintenance Plan
Road Maintenance – Periodical Maintenance

Prepare long-mid term road maintenance plan(budget)

- Prepare long-mid term maintenance plan based on actual data (inventory, inspection, repair history information)
- Find future demand of repair cost and impact analysis between budget and Level of Service

**Condition data**
- Repair method
- Repair cost
- Budget constraint
- Repair criteria
- Prioritization

**Inspection data** (damage level)

**Road Inventory** (Road width, Road Status, Public facility, Traffic volume and Special area)

Long-Mid term Maintenance Plan
Road Maintenance – Road Asset Management

Annual reporting, asset evaluation

- Summarize current situation of facility condition, inspection results, repair construction records for reporting and asset evaluation

Inspection data

Road Inventory

Repair Information

Asset evaluation summary (samples)
Investigation for actual conditions of pavement maintenance in European Countries

- Japanese government (MLIT) is trying to make a restructure pavement maintenance and inspection scheme
- To study actual condition of pavement maintenance work in your countries
  - Pavement inspection, data collection method
  - Data items to be collected
  - Pavement repair scheme, standard
  - Criteria for repair

Thank you for your kind cooperation!