POTENTIAL FOR AUTOMATION OF ROAD CONDITION REPORTING SERVICES

Administered by
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Current Road Condition Reporting Practices

Four basic stages

- Observe field conditions
- Communicate field conditions
- Consolidate observations and transform to digital format
- Generate and disseminate reports
Explore technologies to automate road condition reporting

- Potential approaches
  1. Automate current practices
  2. Use non-contact infrared imagery on mobile platform
  3. Integrate Maintenance Decision Support System techniques
  4. Develop image analysis techniques
  5. Create a decision logic integration of multiple sensors
  6. Develop social networking solutions
Challenge

Duplicate the human ability to integrate multiple sources of information to determine road condition

- **Visual appearance**
  - Light absorption, reflection, refraction
    - Color changes
    - Spectral reflection patterns
    - Isotropic reflection
Challenge

Duplicate the human ability to integrate multiple sources of information

- **Visual appearance**
  - Light absorption, reflection, refraction
  - Changes over time
    - Splatter
    - Surface pattern changes
    - Depth irregularities
Challenge

Duplicate the human ability to integrate multiple sources of information

- **Visual appearance**
  - Light absorption, reflection, refraction
  - Changes over time

- **Obstructions to visibility**
  - Reductions related to precipitation intensity
  - Fog/mist
  - Blowing snow
  - Smoke/haze
Challenge

Duplicate the human ability to integrate multiple sources of information

- **Visual appearance**
  - Light absorption, reflection, refraction
  - Changes over time

- **Obstructions to visibility**

- **Sounds**
  - Rainfall
  - Sleet/hail
Challenge

Duplicate the human ability to integrate multiple sources of information

- **Visual appearance**
  - Light absorption, reflection, refraction
  - Changes over time

- **Obstructions to visibility**

- **Sounds**

- **Sense of feel**
  - Impact with body
  - Slipperiness
Challenge

Duplicate the human ability to integrate multiple sources of information

- Visual appearance
  - Light absorption, reflection, refraction
  - Changes over time

- Obstructions to visibility

- Sounds

- Sense of feel

- Odor
Challenge

Duplicate the human ability to integrate multiple sources of information

- Visual appearance
  - Light absorption, reflection, refraction
  - Changes over time
- Obstructions to visibility
- Sounds
- Sense of feel
- Odor

IT IS A COMPLEX PROCESS AND A CHALLENGE TO AUTOMATE
Explore technologies to automate road condition reporting

- **Potential approaches**
  1. Automate current practices
  2. Use non-contact infrared imagery on mobile platform
  3. Integrate Maintenance Decision Support System techniques
  4. Develop image analysis techniques
  5. Create a decision logic integration of multiple sensors
  6. Develop social networking solutions
1. Automate current practices

Possible Enhancements

- **In the Field**
  - Establish efficient data input technique
    - Preferably a voice recognition system
    - Optionally input via a mobile device app
  - Utilize improved communications networks
  - Establish direct link to central site

- **At the Central site**
  - Quality check and confirmation of observation
  - Immediate composition of road condition report for single site
  - Composition of multiple reports into bulletin and dissemination to users
Explore technologies to automate road condition reporting

- **Potential approaches**
  1. Automate current practices
  2. Use non-contact infrared imagery on mobile platform
  3. Integrate Maintenance Decision Support System techniques
  4. Develop image analysis techniques
  5. Create a decision logic integration of multiple sensors
  6. Develop social networking solutions
6. Social networks & Connected Vehicle

Enhancements

- **Field**
  - Establish efficient data input technique
    - Preferably a voice recognition system *(dependent on auto industry)*
    - Optionally input via a mobile device ap
  - Connected Vehicle program options
  - Establish direct link to central site

- **Central site**
  - Quality check and confirmation of observation
  - Integration of non-public sources into automation procedures
2. Mobile non-contact infrared imagery

Technique

- Use mobile platform to measure all or part of these parameters:
  - Thickness of water, snow, and ice components of sfc material
  - Temperature of the road surface or the upper surface of the materials atop the road
  - Air temperature
  - Relative humidity
2. Mobile non-contact infrared imagery

Technique

- Output
  - Road condition
    - Dry
    - Damp
    - Wet
    - Snow
    - Ice
  - Thickness of water, snow, and ice components
  - Grip
  - Air temperature
  - RH
  - Dew point temperature
2. Mobile non-contact infrared imagery

Current capabilities/assets

- Provides mobile assessment of conditions
- Outputs partial set of road conditions
- Correlates components to grip factor
- Provides thickness of water, snow, and ice components for thin film situations
- Outputs pavement temperature and dew point temperature to support guidance on possible frost conditions
2. Mobile non-contact infrared imagery

Limitations

- IR technique cannot discriminate thickness of components
  - When depths exceed a thin film depth
  - When snow layer forms on top of existing materials
- Sensors do not output variable depths common with traffic
- Research indicates:
  - That snow and water depth measurements are marginally accurate
  - The grip values provide irregular levels of accuracy to actual conditions
3. MDSS

Technique – Estimation or simulation of current conditions

- Mass flux of materials on and off pavement:
  - Water, snow, ice, chemicals, abrasives, and water vapor
- Changes in state of water (water, ice, and vapor)
- Movement of snow, water, and slush due to traffic
- The effects of applied chemicals on the phase state of the water and ice components
- The temperature flux due to:
  - Weather conditions
  - Latent heat changes
  - Heat flux from sub pavement materials
  - Heat capacity and flow through pavement
3. MDSS

Input to support simulation model (hourly or less)
- Precipitation type, intensity, & amount
- Air & dew point temperature
- Wind direction & speed
- Solar radiation flux & net radiation balance (or cloud cover to compute)
- Time of plowing
- Material application time, type & rate
- Surface character of surrounding snow
- Depth of snow in fields surrounding highway
- Traffic volume, speed, and type of vehicle

Output
- Road condition specified in detailed classes
- Mass (depth) of water, snow, ice
- Percent ice and pavement temperature
3. MDSS

Critical input parameters - typically
- Precipitation type, intensity, & amount
- Solar radiation flux & net radiation balance (or cloud cover to compute)
- Time of plowing
- Material application time, type & rate

Critical input parameters – blowing snow
- Surface character of surrounding snow
- Depth of snow in fields surrounding highway
- Wind direction and speed
3. MDSS

Issues

- Route segment specific precipitation info extremely important but there are limited tools to provide good values
- Solar & net radiation must be estimated
- MDC/AVL is source of maintenance activity and a critical piece of info
  - MDC/AVL is not a mature program and not available in many locations
  - MDC/AVL is unreliable for a number of reasons

Result

- Simulation model has significant input deficiencies and accuracy limitations

Impact

- Considerable improvement is needed in input resources before road conditions can be simulated accurately
4. Image Analysis

Approach

- Create an image processing technique that can analyze fixed images to determine road condition
- Develop algorithms or logic that uses the visual cues discussed earlier to determine road and weather condition classifications
- Perform this analysis continually in time steps and integrate the results from the time steps into an aggregate determination of road conditions for a specified period of time

Status

- Image analysis techniques exist; the logic to determine road conditions does not
- Development cost may be a barrier
5. Multiple Sensor Aggregation

Issue
- Human assessment of road condition uses many factors
- Current RWIS sensors measure one or or possibly two parameters
- Field or onboard controllers integrate sensor combinations
- No combination has been effective at duplicating the ability of human observation

Approach
- Evaluate procedures to combine existing sensors to provide more exacting assessment of road conditions
- Vendors are evaluating/developing new solutions
Conclusions and Recommendations

- End-to-end automation of current reporting system
  - Add Interactive Voice Recommendation in maintenance vehicles
  - Create a direct communication interface to central system
  - Establish data transfer design to assure data can move efficiently from field to the user

- Develop a camera system and network to automatically evaluate road conditions
  - Develop an image analysis system
  - Establish a network of new or existing cameras as source of road cond info

- Implement a non-contact sensor network to assist road cond reports
  - Network may use stationary or mobile sensing devices
  - Improve the performance of non-contact sensors to work in all conditions
  - Integrate other observations to improve quality of road cond classes
Conclusions and Recommendations

- **MDSS**
  - Will require maturation of MDC/AVL capabilities
  - Will require improvement in ability to determine precipitation accurately at all locations
  - Requires improvement in estimates of key weather parameters at route level

- **Multiple sensor solutions**
  - Partial combinations exist but their output is incomplete for road conditions
  - Research is needed to determine more robust solutions

- **Social networking / Connected Vehicle**
  - Connected vehicle has tremendous promise but needs much development
  - Social networking has potential but will require development of data assimilation process and quality control techniques
  - Legal considerations with non-government sources will need resolution
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