Micro and Macro Analysis of Railroad Grade Crossing Safety

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Integrate 3 Components

1. Accident analysis (micro)
2. Real-time prediction and monitoring of conflicts
3. Location and operation of emergency response resources
Micro and Macro Analysis (Component 1)

Micro Analysis (at single crossing or corridor):
- Trend discovery using a dynamic tree
- Identification of contributing factors
- Quantify accident occurrence and risk

Macro Analysis (at regional/national level):
- Statistical models to integrate Micro Analysis findings
- Evaluating effects of new variables found micro analysis
- Comparisons with current prediction models
Micro Approach – Single Crossing

• Initially started as a manual process (done by person)

• **Three steps in manual process:**
  1. Sketch of crossings with key info
  2. Follow the tree structure (hierarchy is given) to spot trends
  3. Bring in additional information (e.g. surroundings, land use, nearby ramps)
A Micro Approach – Single Crossing

- Sketch of crossings with key info:
Manual Micro Approach Hierarchy

- Order of attributes

- Highway User Type
  - (typeveh)

- Action of Motorist
  - (motorist)
  - 1 = Drove around or thru the gate
  - 2 = Stopped and then proceeded
  - 3 = Did not stop
  - 4 = Stopped on crossing
  - 5 = Other

- Highway User Direction
  - (vedir)
  - 1 = north, 2 = south, 3 = east, 4 = west
  - (Depend on the actual Geometrical direction on the map)

- Time Table Direction
  - (unidir)
  - 1 = north, 2 = south, 3 = east, 4 = west
  - (Depend on the actual Geometrical direction on the map)

- Circumstance of Accident
  - (typacc)
  - 1 = rail equipment struck highway user
  - 2 = rail equipment struck by highway user

- Vehicle Driver Age and Gender
  - (driverage, drivgen)
  - (drivage): Numerical value of the age
  - (drivgen): 1 = male, 2 = female

- Weather Condition and Visibility
  - (weather, visibility)
  - (weather): 1 = clear, 2 = cloudy, 3 = rain
  - 4 = fog, 5 = sleet, 6 = snow
  - (visibility): 1 = dawn, 2 = day, 3 = dusk, 4 = dark

- K = Pedestrian
  - A-J = Motorized vehicle
  - M = Other
Manual Micro Approach – Single Crossing

Example 1: crossing with 9 Accidents (17387G)

Trend?
EB train hits SB vehicles
Example 2: Crossing with 5 accidents

- In 4 of 5 accidents, drivers was older than 80
- The youngest driver was 61 years old!

Why such a trend?
Bringing in more data

Example 2 (Cont...)

• Revealed high concentration of assisted living communities.

• So, countermeasures should focus on older drivers

• How findings like this can be used at macro level?
Improvements to Manual Micro Approach

- Computerize the process to reduce time, expand it application, etc
- Determine the hierarchy dynamically (data driven vs pre-determined)
- Consider more attributes than the manual method (e.g. 7 vs 22)
- Use more than one attribute at a time
Methods for Determining Hierarchy

• Method A
  • Distribute the total number of accidents into the subcategories for each of the 22 attributes
  • Sort the attributes based on the largest subcategory of accidents to determine the hierarchy
  • Establish a main branch of the tree by sequentially dividing the largest subcategory for Attribute 1 into subcategories for Attribute 2 based on the established hierarchy; ....and so on

  – Advantages
    • Simple and hierarchy relies on the distribution of accidents into subcategories for this crossing

  – Disadvantage
    • Another hierarchy may identify the trend in the main branch “better” than Method A by keeping a higher number of accidents in subcategory at comparable level
Methods for Determining Hierarchy

• Method B
  • Establish the highest ranking attribute as in Method A
  • Divide the accidents in the largest subcategory of Attribute 1 into subcategories of the un-selected attributes to determine the 2nd highest ranking attribute
  • This stepwise procedure is continued to determine the 3rd, 4th, 5th... highest ranking attributes

  – Advantages
    • Keeps the trend in the main branch of the tree better than Method A
  – Disadvantage
    • There may be ties in ranking of the attributes
    • This focus on the main branch and does not consider the accident on other branches
Methods for Determining Hierarchy

• Modified Method B
  • Use historic accident data to resolve ties in establishing the hierarchy
  • It finds “Crossing Cluster” which is the sum of no accidents in all branches of an attribute for the subcategory that identified the trend in main branch

• Advantages of Modified Method B
  • Keeps accidents clustered together without breaking trend
  • Can detect over/under representation
  • Shows “Crossing Cluster” information to give a big picture
  • Can be used to identify trends on various crossings
Level of Analysis Using the Dynamic Tree

• Single location with multiple accidents
  – Dynamic tree
  – Simultaneously using two or more attributes

• Multiple locations
  – Dynamic tree for a corridor
  – Dynamic tree for all single-accidents location combined
Single Location With Multiple Accidents (computerized)

Crossing with 9 accidents (173887G)

**DYNAMIC TREE**
- Total (9)
  - Motorists (8)
  - Ped (1)
    - <20 (8)
      - East (7)
      - West (1)
    - Rail->HW (6)
    - HW->Rail (1)
  - 30-60 (6)
    - Stopped on Crossing (5)
      - Yes (4)
      - South (4)
      - Others (4)
    - Moving Over Crossing (1)
      - Unknown (1)
      - North (1)
      - North(1)
- TYPVEH
- VEHspd
- TRNDR
- TYPACC
- DRIVAGE
- POSITION
- WARNSIG
- VEHDIR
- MOTORIST

**ATTRIBUTES**
- Total
- TYPVEH
- VEHspd
- TRNDIR
- TYPACC
- DRIVAGE
- POSITION
- WARNSIG
- VEHDIR
- MOTORIST

**CROSSING CLUSTER**
- Motorized vehicles (8)
  - <20 (8)
    - East (7)
    - Rail->HW (7)
    - 30-60 (7)
  - Stopped on Crossing (5)
    - Yes (7)
    - South (5)
      - Drove Around (4)
      - Other (4)
Observations about the previous slide

- 7 out of 8 accidents involved an EB train
- In 6 out of the 7 accidents, train hit the highway vehicle
- In 5 out of the 7 accidents, vehicles were stopped on crossing
- 4 out of the 5 accidents were SB vehicles
- Action of motorist in all 4 accidents was “other”,
  - “Other” meant the motorists stopped on crossing before the gates descended
Comparison of Dynamic vs Manual Method

- Dynamic hierarchy is based on accident data for that crossing, but Manual method is based on a pre-determined hierarchy

- Computerized method kept trends of the Manual method AND revealed more info than the manual

- Even when the same attributes are considered, the ranking of the attributes can be different in two methods

- Using a computer program makes process quicker with no chance for errors
Multiple Locations

- Corridor Analysis
- Analysis of all single accident locations combined
Example Corridor

- Northeast Illinois Regional Commuter Railroad
- 23 accidents at 8 crossings between 2002 and 2011
Corridor Analysis

Dynamic Tree

- Total
  - Passing Train (1)
  - Not Obstructed (22)
    - Motor Vehicle (22)
      - Both Sides (21)
        - Side of Vehicle Approach (1)
          - Main (20)
            - Rail->HW (17)
              - North (3)
                - < 20 (11)
                  - AM (5)
                    - Stopped on Crossing (2)
                      - Driven Around Gate (6)
                - 20-40 (1)
                  - PM (8)
                    - Moving Over Crossing (6)
              - South (14)
                - 40-60 (4)
      - HW->Rail (5)
          - Yard (1)

Attributes

- View
- Type Veh
- Location
- Type Track
- Type of Accident
- Tread Direction
- Vehicle Speed
- Time
- Position
- Motorist

Corridor Cluster

- Not Obstructed (22)
  - Vehicle (22)
    - Both Sides (22)
      - Main (21)
        - Rail->HW (19)
          - South (15)
            - < 20 (15)
              - AM (12)
                - PM (4)
          - Moving Over Crossing (18)
            - Driven Around (15)
Observations about the previous slide

• 19 out of 23 cases involve rail hitting the highway vehicle

• 14 out of 22 vehicles were hit by a south bound train
  • Any reason/cause?

• 18 of the 22 motor vehicle accidents involved the vehicle moving over the crossing

• 14 out of 22 accidents occurred during PM
Locations with one Accident
Dynamic Tree for Single Locations with Crossbucks

**DYNAMIC TREE**

- **Total (207)**
  - **Motor Vehicle (204)**
    - **Permanent Obstruction**
    - **Vegetation (2)**
    - **HW Vehicle (1)**
      - **Other (1)**
  - **Ped (1)**
  - **Other (2)**
    - **Not Obstructed (194)**
      - **Both Sides (183)**
        - **Main (171)**
          - **Yes (6)**
          - **No (148)**
          - **Unknown (3)**
        - **Yard (3)**
        - **Siding (1)**
        - **Industry (8)**
      - **Side of Approach (11)**
  - **Unknown (17)**
  - **Rail -> HW (97)**
  - **HW -> Rail (20)**
  - **Dawn (3)**
  - **Day (79)**
  - **Dusk (2)**
  - **Dark (13)**
  - **Clear (63)**
  - **Cloudy (16)**
  - **<20 (50)**
  - **20-40 (101)**
  - **>40 (3)**
  - **Male (41)**
  - **Female (9)**

**ATTRIBUTES**

- **TOTAL**
  - **TYPVEH**
  - **VIEW**
  - **LOCWARN**
  - **TYPTRK**
  - **LIGHTS**
  - **WARNSIG**
  - **TYPACC**
  - **VISIBILITY**
  - **WEATHER**
  - **VEHDSRD**
  - **DRIVGEN**

**CLUSTER**

- **Motor Vehicle (204)**
  - **Unobstructed (200)**
  - **Both Sides (196)**
    - **Main (191)**
  - **No (166)**
  - **No (158)**
  - **Rail -> HW (157)**
  - **Day (155)**
  - **Clear (137)**
  - **<20 (144)**
  - **40-60 (21)**
  - **Male (162)**
Dynamic Tree for Single Locations with Fl.Lights

**Dynamic Tree**

- Total (147)
  - Both Sides (143)
  - Side of Approach (2)
  - Opposite Side (2)
    - Unobstructed (136)
      - Ped (4)
      - Motorist (127)
      - Others (5)
        - Main (118)
        - Yard (4)
        - Siding (1)
        - Industry (4)
          - Stalled (3)
          - Stopped (20)
          - Moving (94)
          - Trapped (1)
            - Stopped and Proceeded (15)
              - Yes (3)
              - No (63)
              - Unknown (10)
                - Clear (46)
                - Cloudy (9)
                - Rain (1)
                - Fog (3)
                - Snow (4)

**Attributes**

- TOTAL
- LOCWARN
- VIEW
- TYPVEH
- TYPTRK
- POSITION
- MOTORIST
- WARNSIG
- WEATHER

**Cluster**

- Both Sides (143)
- Unobstructed (140)
- Motorist (138)
- Main (137)
- Moving (120)
- Did not stop (97)
- No (113)
- Clear (98)
Observations from Previous Slides

• All-single-accident-locations-combined did not reveal trend,
  - But dividing it into: gated, flashing lights, cross buck did.

• Most Pedestrian accidents occurred at gated crossings (55 out of 60)

• Most accidents during dark occurred at gated crossings (162 out of 257)

• Most accidents with vehicle speed > 40 occurred at cross bucks (21 out of 56)

• Therefore it is important create dynamic tree for the “right” subset of data.
Work in Progress

• Validation
  - Different dataset from one state, data from different state
• Analysis involving more than one attributes
  - Extending this to multiple attributes
• Various combinations of attributes at multiple accident locations

• Integrate the findings from micro in building macro model

• Develop Integrated micro and macro levels

• Compare new macro model to current accident prediction model.
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Thanks!

Questions?

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