Regional Traffic Operations Committee

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City of Bellevue, WA
Safer People, Safer Streets

USDOT Headquarters: September 16, 2016

Bellevue, WA, pursued a range of data collection activities during the Mayors’ Challenge to identify barriers to bicycling and walking, prioritize improvements, and guide investments. In February 2015, the Bellevue City Council introduced the Pedestrian and Bicycle Implementation Initiative (PBI) to improve safety for people of all ages and abilities who walk and bike in Bellevue. Using data collected from online sources, key-ped polling at public meetings, automated bicycle and pedestrian counts, and traffic camera video, the PBI team identified barriers to walking and bicycling and developed a $6.8M Bicycle Rapid Implementation Program (BRIP) budget proposal to guide potential investments through 2019. The BRIP aims to expand the city’s bicycle network from 42 miles to more than 70 miles of conventional bike lanes, separated lanes or off-street paths, and to complete four continuous, cross-city bicycle corridors.

Demonstrated Successes

Innovative Data Collection Techniques Gather Real-Time and Long-Term Data with Public Input

Throughout the PBI process, Bellevue has emphasized understanding long-term trends and gathering feedback from people who walk and bike. Bellevue’s PBI team:

- Conducted a longitudinal assessment from 2006-2015 of non-motorized collisions using the USDOT’s Pedestrian and Bicycle Crash Analysis Tool (PB-CAT) system;
- Gathered input using key-ped polling and comment cards at 20 public meetings and an open house that attracted 140 attendees; and
- Used online surveys to solicit public input at two stages in the BRIP development process:
  - Over 700 people placed more than 1,600 points in the first online map to identify locations that they felt were unsafe for walking and bicycling;
  - Over 120 people submitted more than 400 comments on conceptual designs for 52 proposed projects to make the pedestrian and bicycle systems safer.
### Worldwide: Traffic Fatalities

**Leading Causes of Death (2004)**

<table>
<thead>
<tr>
<th>RANK</th>
<th>LEADING CAUSE</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ischaemic heart disease</td>
<td>12.2</td>
</tr>
<tr>
<td>2</td>
<td>Cerebrovascular disease</td>
<td>9.7</td>
</tr>
<tr>
<td>3</td>
<td>Lower respiratory infections</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>Chronic obstructive pulmonary disease</td>
<td>5.1</td>
</tr>
<tr>
<td>5</td>
<td>Diarrhoeal diseases</td>
<td>3.6</td>
</tr>
<tr>
<td>6</td>
<td>HIV/AIDS</td>
<td>3.5</td>
</tr>
<tr>
<td>7</td>
<td>Tuberculosis</td>
<td>2.5</td>
</tr>
<tr>
<td>8</td>
<td>Trachea, bronchus, lung cancers</td>
<td>2.3</td>
</tr>
<tr>
<td>9</td>
<td>Road traffic injuries</td>
<td>2.2</td>
</tr>
<tr>
<td>10</td>
<td>Prematurity and low birth weight</td>
<td>2.0</td>
</tr>
<tr>
<td>11</td>
<td>Neonatal infections and other</td>
<td>1.9</td>
</tr>
<tr>
<td>12</td>
<td>Diabetes mellitus</td>
<td>1.9</td>
</tr>
<tr>
<td>13</td>
<td>Malaria</td>
<td>1.7</td>
</tr>
<tr>
<td>14</td>
<td>Hypertensive heart disease</td>
<td>1.7</td>
</tr>
<tr>
<td>15</td>
<td>Birth asphyxia and birth trauma</td>
<td>1.5</td>
</tr>
<tr>
<td>16</td>
<td>Self-inflicted injuries</td>
<td>1.4</td>
</tr>
<tr>
<td>17</td>
<td>Stomach cancer</td>
<td>1.4</td>
</tr>
<tr>
<td>18</td>
<td>Cirrhosis of the liver</td>
<td>1.3</td>
</tr>
<tr>
<td>19</td>
<td>Nephritis and nephrosis</td>
<td>1.3</td>
</tr>
<tr>
<td>20</td>
<td>Colon and rectum cancers</td>
<td>1.1</td>
</tr>
</tbody>
</table>
USA: Traffic Fatalities

Fatalities and Fatality Rate per 100 Million VMT, by Year, 1965–2015

Vision Zero: Reframing Traffic Deaths & Injuries as Preventable

Amy Carlson, Vice President, CH2M HILL

Vision Zero = All of us getting home safe each night.
From 2005 through 2010 there were 60 collisions recorded by the Bellevue Police Department and the WSP at this location.

In 2013, WSDOT built a new roundabout at the intersection of the WB I-90 on- and off-ramps and WLSP SE/180 Ave SE.
Conflict-Based Approach: Don’t Wait For Crashes to Happen

Hyden’s Safety Pyramid (adapted from Hyden, 1987)
Conflict-Based Approach: Public Involvement Strategy

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Points Placed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ped Facilities</td>
<td>514</td>
<td>32%</td>
</tr>
<tr>
<td>Bike Facilities</td>
<td>573</td>
<td>35%</td>
</tr>
<tr>
<td>Ped Behaviors</td>
<td>57</td>
<td>4%</td>
</tr>
<tr>
<td>Bike Behaviors</td>
<td>22</td>
<td>1%</td>
</tr>
<tr>
<td>Car Behaviors</td>
<td>452</td>
<td>28%</td>
</tr>
<tr>
<td>Total</td>
<td>1618</td>
<td></td>
</tr>
</tbody>
</table>
Leverage a city’s existing traffic camera system to simultaneously:

1. monitor counts and travel speed of all road user groups (vehicle, pedestrian, and bicycle);

2. document the directional volume of all road user groups as they move through an intersection; and,

3. assess unsafe “near-miss” trajectories and interactions between all road user groups.
# Partnership Momentum

## Oversight
- Microsoft
- City of Bellevue, Washington
- University of Washington

## Government
- WSDOT
- SDOT
- New York City DOT
- LADOT
- City of Redmond
- Snohomish County

## Research
- UBC
- Lund University
- McGill
- Polytechnique Montréal

## Non-Profit
- ITS America
- ITE
- Vision Zero Network
- Cascade Bicycle Club
- People for Bikes
**Milestone 1**: Demonstrate the capability of vision technologies by detecting relevant events in the sample traffic videos (e.g., detecting cars, pedestrians, and bikes and tracking their movements).

**Milestone 2**: Demonstrate an end-to-end system that will, continuously in real-time, detect and store the events, and present aggregated information.

**Milestone 3**: Pilot deployment of end-to-end system (running on servers provided by Microsoft) in the City of Bellevue traffic control center. The system will run off of a live feed.

**Milestone 4**: Support additional scenarios (e.g., near-collisions of cars with pedestrians and bikes or patterns of bikers crossing a busy intersection).
Trajectory Detection & Turning Movement Counts
Volume Charts

VEHICLE DISTRIBUTION CHARTS BY TIME OF DAY

MONTH: MAY, 2016
DATE: 5.1.2016 - 5.1.2016

CARS
11pm 12pm 10pm
30,000 cars/day

BUSES/TRUCKS
11pm 12pm 10pm
400 buses & trucks/day

PEDESTRIANS
11pm 12pm 10pm
1,000 pedestrians/day

BICYCLISTS
11pm 12pm 10pm
100 bikes/day
Near-Miss Detection
# Object Classification Accuracy

![Image of a city intersection with objects classified]

## Table of Classification Accuracy

<table>
<thead>
<tr>
<th>Classified-as</th>
<th>Vehicles</th>
<th>Bikes</th>
<th>Peds</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicles</td>
<td>0.95</td>
<td>0.01</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Bikes</td>
<td>0.08</td>
<td>0.67</td>
<td>0.16</td>
<td>0.08</td>
</tr>
<tr>
<td>Peds</td>
<td>0.15</td>
<td>0.15</td>
<td>0.73</td>
<td>0.05</td>
</tr>
<tr>
<td>None</td>
<td>0.09</td>
<td>0.03</td>
<td>0.11</td>
<td>0.81</td>
</tr>
</tbody>
</table>

We recognized it as...
How Neural Networks Work

**training**
During the training phase, a neural network is fed thousands of labeled images of various objects, learning to classify them.

**input**
A new image is shown to the pretrained network.

**first layer**
The neurons respond to simple shapes, like edges.

**higher layer**
The neurons respond to complex shapes.

**top layer**
Neurons respond to highly complex abstract concepts that we would identify as different objects.

**output**
The network predicts what the object most likely is based on its training.

- **90% ✓**
- **10% ✗**
Winter 2017: Collect Pre-Recorded Traffic Camera Footage
Annotate all objects of interest, moving, stationary, or obstructed, for the entire video.

2016-Sep-10 08:49:30.867 AM (PDT)

What type of object did you just annotate?
- Pedestrian
- B/Cycle
- PedestrianWithStroller
- MotorBike
- Car
- Bus
- Truck
- WheelChair

Pedestrian 2
- Outside of view frame
- Temporarily not visible
- Crossing Road

Pedestrian 1
- Outside of view frame
- Temporarily not visible
- Crossing Road

In this video, please track all of these objects:
- Pedestrian
- B/Cycle
- PedestrianWithStroller
- MotorBike
- Car
- Bus
- Truck
- WheelChair
Winter/Spring 2017: Launch Public Facing Webpage
Winter/Spring 2017: Invite Public to Participate
Summer 2017: Classify Near-Miss Events

<table>
<thead>
<tr>
<th>Focused object</th>
<th>Vehicle</th>
<th>Pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Vehicle time to collision (Vehicle TTC)</td>
<td>Pedestrian time to vehicle (Pedestrian TTV)</td>
</tr>
<tr>
<td>Definition</td>
<td>Vehicle TTC = $L = \frac{Ld}{v}$</td>
<td>Pedestrian TTV = $Ld = \frac{v}{v}$</td>
</tr>
<tr>
<td>Study</td>
<td>Previous study (Matsui et al. 2011b)</td>
<td>Present study</td>
</tr>
</tbody>
</table>

**Time to Collision (Matsui et al., 2013)**

**Post Encroachment Time (Van der Horst et. al., 2014)**

**Swedish Conflict Technique (Hyden et. al., 1987)**
ITS America Meeting (1/9/17)

ITS America
Institute of Transportation Engineers
World Bank
FIA Foundation
International Road Assessment Program
People for Bikes
City of Bellevue
New York City DOT
Los Angeles DOT
University of Washington
McGill University
University of British Columbia
Montreal Polytechnique
Miovision
Fehr & Peers
Brisk Synergies
AKRF
Bellevue's Vision Zero Initiative: From Video Analytics to Corrective Measures

For More Information

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