Moving Observer Method

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Introduction

• **Outline**
  – Point measurement
  – Measurement over a short stretch
  – Measurement over a long stretch
  – Measurement over an area
  – Moving observer method
Introduction

• **Stream characteristics from field**
  – Flow
  – Speed
  – Density, occupancy
  – Travel time
  – Spacing
  – Headway
Measurement Procedures
Moving observer method

• **Overview**
  – Obtain fundamental stream characteristics
  – Observer moves in the traffic stream
  – Derived by Wardrop and Charlesworth (1954)

• **Suitability**
  – Rural traffic, Urban traffic with low volume
  – Driver follows average speed
Moving observer method

- **Derivation**
  - Consider an observer watching a stream of vehicles: two special cases arise:
    - **Case 1**: Moving stream and stationary observer
    - **Case 2**: Moving observer and stationary stream
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• **Case 1: Moving stream - stationary observer**
  - If $n_0$ is the number of vehicles overtaking the observer during a period $t$, then
  - By definition, flow is $q = n_0 / t$
  - Or $n_0 = q \times t$
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• Case 2: Moving observer - stationary stream
  – Let the observer moves with speed $v_o$
  – Let $n_p$ is number of vehicles overtaken by observer over the length $l$
  – By definition density is $k = n_p/l$
  – Or $n_p = k \times l$ \hspace{1cm} $n_p = k \cdot v_o \cdot t$
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• **Case 3: Both stream and observer moving**
  – Observer is moving along the stream
    • General case of Case 1 and Case 2
      
      
      \[ n_0 = q \times t \quad n_p = k v_o t \]

      – Let \( m_0 \) vehicles overtake the observer
      – Let \( m_p \) vehicles overtaken by the observer

      \[ m = m_0 - m_p = q t - k v_o t \]
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- Case 3: Both stream and observer moving
  - Moving stream: stationary observer $v_o=0$
    \[ m = m_0 - m_p = q t - k v_o t \]
  - Stationary stream, moving observer
  - Let $m_0$ vehicles overtake the observer
  - Let $m_p$ vehicles overtaken by the observer
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- **Case 3: Both stream and observer moving**
  - To get both $q$ and $v$, we need two equations
  - Possible by two trips or a reverse trip

\[
\begin{align*}
m_w &= q \, t_w - k \, v_w \, t \\
&= q \, t_w - k \, l \\
m_a &= q \, t_a + k \, v_a \, t_a \\
&= q \, t_a + k \, l
\end{align*}
\]
• **Case 3:** Both stream and observer moving

- Solving for \( q \), we get

\[
\begin{align*}
m_w &= q \ t_w - k \ l \\
m_a &= q \ t_a + k \ l \\
q &= \frac{m_w + m_a}{t_w + t_a}
\end{align*}
\]
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- Derivation of $v_s$

\[
\frac{m_w}{t_w} = q - ku_w
\]
\[
= q - \frac{q}{v} v_w
\]
\[
= q - \frac{q}{v} \left[ \frac{l}{t_w} \right]
\]
\[
= q \left( 1 - \frac{l}{v} \times \frac{1}{t_w} \right)
\]
\[
= q \left( 1 - \frac{t_{avg}}{t_w} \right)
\]
\[
t_{avg} = \frac{l}{v_s}
\]

\[
k = \frac{q}{v_s}
\]

\[
v_s = \frac{l}{t_w - \frac{m_w}{q}}
\]

\[
\frac{m_w}{q} = t_w \left( 1 - \frac{t_{avg}}{t_w} \right) = t_w - t_{avg}
\]

\[
t_{avg} = t_w - \frac{m_w}{q} = \frac{l}{v}
\]
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• **Proof**

- Vehicles counted in $t_w + t_a$ by an observer at A is same as
- All vehicles against in DN direction, plus
- Overtaken in UP direction, minus
- All vehicles passed by in UP direction
- This is the flow $q = \frac{m_w + m_a}{t_w + t_a}$
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• **Example 1**
  – Length of the road stretch = 0.5 km
  – Speed of test vehicle = 20 km/hr
  – No of vehicles encountered while moving against the traffic stream = 107
  – No of veh. overtaken the test vehicle = 10
  – No of veh. overtaken by the test vehicle = 74
  – Find the flow, density and mean speed
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Solution

Time taken by the test vehicle to reach the other end of the stream while it is moving along with the traffic is $t_w = \frac{0.5}{20} = 0.025$ hr. Time taken by the observer to reach the other end of the stream while it is moving against the traffic is $t_a = t_w = 0.025$ hr. Flow is given by equation, $q = \frac{107+(10-74)}{0.025+0.025} = 860$ veh/hr. Stream speed $v_s$ can be found out from equation $v_s = \frac{0.5}{0.025-10.74 \over 860} = 5$ km/hr. Density can be found out from equation as $k = \frac{1}{v_s} = 172$ veh/km.
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**Example 2**

- Col. 2: no of veh moving against the stream
- Col. 3: no of veh overtaken the test vehicle
- Col. 4: no of veh. overtaken by the test vehicle
- Length = 0.5 km
- $ta = tw = 0.025$ hrs

<table>
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<th>No</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
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<td>10</td>
<td>74</td>
</tr>
<tr>
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<td>113</td>
<td>25</td>
<td>41</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>79</td>
<td>18</td>
<td>9</td>
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</tbody>
</table>
## Moving observer method

### Solution

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>$m_a$</th>
<th>$m_o$</th>
<th>$m_p$</th>
<th>$m(m_o - m_p)$</th>
<th>$t_a$</th>
<th>$t_w$</th>
<th>$q = \frac{m_a + m_w}{t_a + t_w}$</th>
<th>$u = \frac{l}{t_w - \frac{m_a}{q}}$</th>
<th>$k = \frac{q}{u}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>107</td>
<td>10</td>
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<td>25</td>
<td>41</td>
<td>-16</td>
<td>0.025</td>
<td>0.025</td>
<td>1940</td>
<td>15.04</td>
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</tr>
<tr>
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<td>5</td>
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<td>0.025</td>
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<td>40</td>
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</tr>
<tr>
<td>4</td>
<td>79</td>
<td>18</td>
<td>9</td>
<td>9</td>
<td>0.025</td>
<td>0.025</td>
<td>1760</td>
<td>25.14</td>
<td>70</td>
</tr>
</tbody>
</table>
Moving observer method
Moving observer method
Moving observer method

- **Limitation**
  - Unsuitable for large traffic
  - Unsuitable if there is major turning traffic
  - Large number of observations required to estimate reliable data
  - Driver bias
Thank You

Questions?