AIS Point Prediction Problem

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DEFCON
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Point Prediction Problem

Statement

• Given a single point (lat, long) and a ship's speed over ground (SOG), course over ground (COG), and rate-of-turn (ROT), predict an area of the ship's next point
Source of Information

• AIS Type 1, 2, and 3 Position Report Class A
  • Latitude (0-90° north [+]; 0-90° south [-])
    • 1° latitude = 60 nm
  • Longitude (0-180° east [+]; 0-180° west [-])
    • 1° longitude ≈ 60 nm at the Equator (0° latitude)
    • At other latitudes, 1° longitude = f(latitude) [See appendix]
  • Course (degrees; 0° = true north)
  • Speed (kn; 1 knot = 1 nm/hour = 1.151 MPH)
  • Rate of turn (°/min; left [-], right [+])
  • Time between transmissions = f(SOG,ROT)
    • The standard is not always reality
## Position Message Frequency

<table>
<thead>
<tr>
<th>Transponder Type</th>
<th>Vessel's Moving Status (Transponder ON)</th>
<th>AIS Transmission Rate</th>
<th>Max. Distance Traveled (1 nm ≈ 2,000 yds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>Anchored / Moored</td>
<td>Every 3 Minutes</td>
<td>Negligible</td>
</tr>
<tr>
<td>Class A</td>
<td>Sailing 0-14 knots</td>
<td>Every 10 Seconds</td>
<td>77 yds</td>
</tr>
<tr>
<td>Class A</td>
<td>Sailing 14-23 knots</td>
<td>Every 6 Seconds</td>
<td>77 yds</td>
</tr>
<tr>
<td>Class A</td>
<td>Sailing 0-14 knots and changing course</td>
<td>Every 3.33 Seconds</td>
<td>26 yds</td>
</tr>
<tr>
<td>Class A</td>
<td>Sailing 14-23 knots and changing course</td>
<td>Every 2 Seconds</td>
<td>26 yds</td>
</tr>
<tr>
<td>Class A</td>
<td>Sailing faster than 23 knots</td>
<td>Every 2 Seconds</td>
<td>33 yds @ 30 kn</td>
</tr>
<tr>
<td>Class A</td>
<td>Sailing faster than 23 knots and changing course</td>
<td>Every 2 Seconds</td>
<td>33 yds @ 30 kn</td>
</tr>
<tr>
<td>Class B</td>
<td>Stopped or sailing up to 2 knots</td>
<td>Every 3 Minutes</td>
<td>198 yds</td>
</tr>
<tr>
<td>Class B</td>
<td>Sailing faster than 2 knots</td>
<td>Every 30 Seconds</td>
<td>500 yds @ 30 kn</td>
</tr>
</tbody>
</table>

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Known from AIS transmission:
- Course over ground, COG
- Lat_0, Long_0
- Rate-of-turn, ROT (ω)
- Speed over ground, SOG (V)
- Est. time between transmissions (T)

Can compute:
- R = V / ω
- D = V x T
- θ = D / 2πR
- Δx = f(θ, SOG, T)
- Δy = f(θ, SOG, T)
- ΔLat = f(COG+θ, Δx, Δy)
- ΔLong = f(COG+θ, Δx, Δy, f(Lat_0))

- Lat_1 = Lat_0 + Δy
- Long_1 = Long_0 + f(Δx, Lat_0)

NOTE: We are actually working with small distances. If SOG = 15 kn, that is 0.25 nm/min or ~500 yds/min. If the ship is reporting every 2 sec., that means that the ship has traveled about ~17 yds between reports...
Targets

• Position ahead is $f(SOG,T,ROT)$
  • If $ROT=0$, ship is moving in a straight line
  • If $ROT\neq 0$, ship is turning

• Can alter predictive box by changing "gain"
  • Cone of predictive points increases as $ROT$ increases
Appendix: Length of 1° Lat/Long

\[
\text{length of 1° latitude (meters)} = 111132.92 + (-559.82 \times \cos\(2\times\text{lat}\)) + (1.175 \times \cos\(4\times\text{lat}\)) + (-0.0023 \times \cos\(6\times\text{lat}\))
\]

\[
\text{length of 1° longitude (meters)} = (111412.84 \times \cos\(\text{lat}\)) + (-93.5 \times \cos\(3\times\text{lat}\)) + (-0.118 \times \cos\(5\times\text{lat}\))
\]

To calculate the distance between two points, given their latitude and longitude, see https://www.nhc.noaa.gov/gccalc.shtml
Appendix: Length of 1° Lat/Long

These formulas are the basis for the "Length of a Degree of Latitude and Longitude Calculator" web sites at https://msi.nga.mil/msisitecontent/staticfiles/calculators/degree.html and http://www.csgnetwork.com/degreeenllavcalc.html, and yield the following table:

<table>
<thead>
<tr>
<th>Latitude</th>
<th>One degree of latitude</th>
<th>One degree of longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sm</td>
<td>nm</td>
</tr>
<tr>
<td>Equator (0°)</td>
<td>68.71</td>
<td>59.71</td>
</tr>
<tr>
<td>10°</td>
<td>68.73</td>
<td>59.72</td>
</tr>
<tr>
<td>20°</td>
<td>68.79</td>
<td>59.78</td>
</tr>
<tr>
<td>30°</td>
<td>68.88</td>
<td>59.86</td>
</tr>
<tr>
<td>40°</td>
<td>68.99</td>
<td>59.95</td>
</tr>
<tr>
<td>50°</td>
<td>69.11</td>
<td>60.06</td>
</tr>
<tr>
<td>60°</td>
<td>69.23</td>
<td>60.16</td>
</tr>
<tr>
<td>70°</td>
<td>69.32</td>
<td>60.24</td>
</tr>
<tr>
<td>80°</td>
<td>69.38</td>
<td>60.29</td>
</tr>
<tr>
<td>Poles (90°)</td>
<td>69.40</td>
<td>60.31</td>
</tr>
</tbody>
</table>

Key: sm = statute miles; nm = nautical miles; km = kilometers

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Contact Information

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