AIS Point Prediction Problem

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DEFCON

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Point Prediction Problem Statement

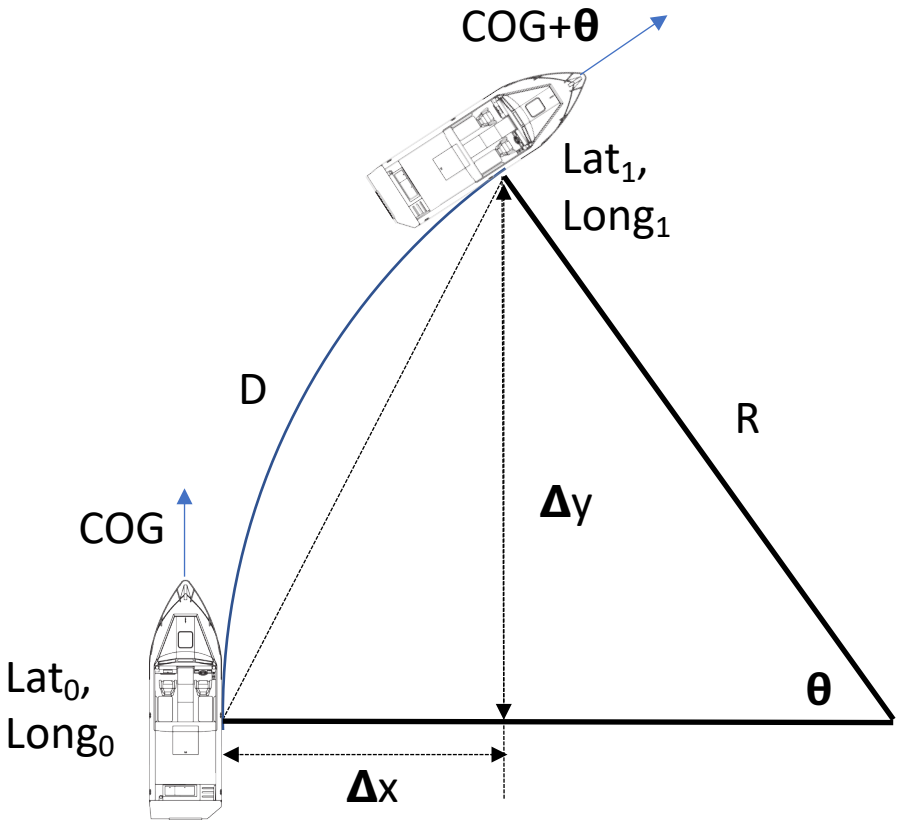
- Given a single point (lat, long) and a ship's speed over ground (SOG), course over ground (COG), and rate-of-turn (ROT), predict an area of the ship's next point

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° longtitude ≈ 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

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



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…

Known from AIS transmission:

- Course over ground, COG
- Lat_0, $Long_0$
- Rate-of-turn, ROT ($\boldsymbol{\omega}$)
- Speed over ground, SOG (V)
- Est. time between transmissions (T)

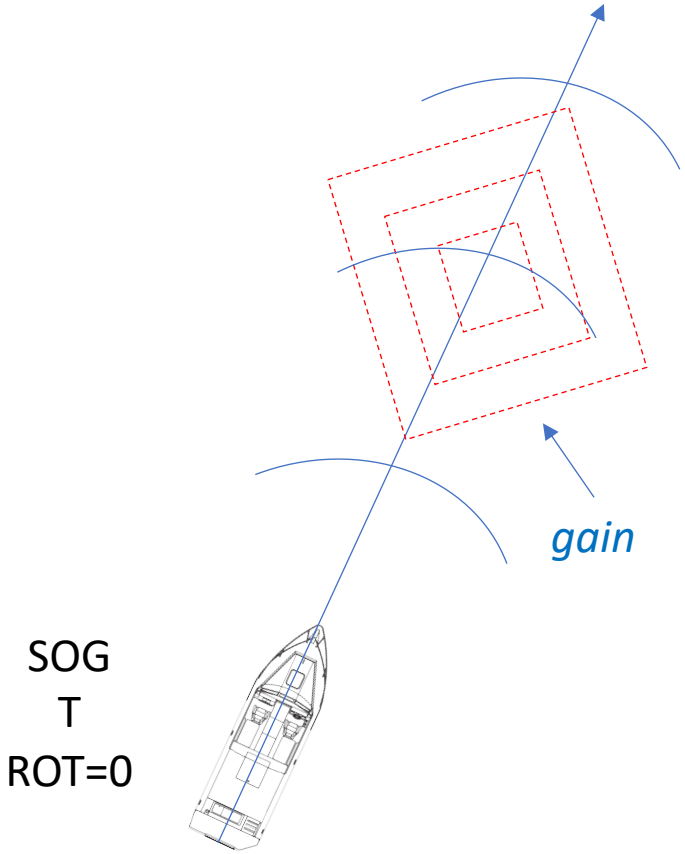
Can compute:

- $R = V / \boldsymbol{\omega}$
- $D = V \times T$
- $\boldsymbol{\theta} = D / 2\pi R$
- $\boldsymbol{\Delta}x = f(\boldsymbol{\theta}, SOG, T)$
- $\boldsymbol{\Delta}y = f(\boldsymbol{\theta}, SOG, T)$
- $\boldsymbol{\Delta}Lat = f(COG+\boldsymbol{\theta}, \boldsymbol{\Delta}x, \boldsymbol{\Delta}y)$
- $\boldsymbol{\Delta}Long = f(COG+\boldsymbol{\theta}, \boldsymbol{\Delta}x, \boldsymbol{\Delta}y, f(Lat_0))$

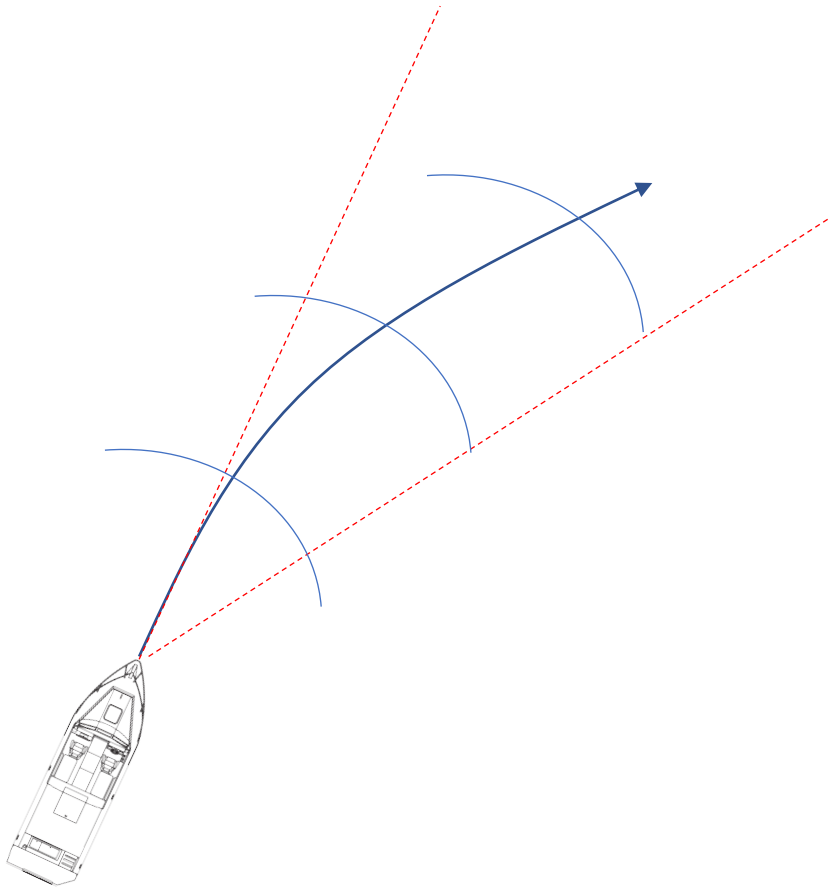
- $Lat_1 = Lat_0 + \boldsymbol{\Delta}y$
- $Long_1 = Long_0 + f(\boldsymbol{\Delta}x, Lat_0)$

Targets

- Position ahead is *f*(SOG,T,ROT)
  - If ROT=0, ship is moving in a straight line
  - If ROT≠0, ship is turning
- Can alter predictive box by changing "gain"
  - Cone of predictive points increases as ROT increases



SOG
T
ROT=0



SOG
T
ROT≠0

Appendix: Length of 1° Lat/Long

length of 1° latitude (meters) = 111132.92 + (-559.82 × cosine (2×lat)) +
(1.175 × cosine (4×lat)) + (-0.0023 × cosine (6×lat))

length of 1° longitude (meters) = (111412.84 × cosine (lat)) + (-93.5 × cosine (3×lat))
+ (-0.118 × cosine (5×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/degreelenllavcalc.html*, and yield the following table:

Latitude	One degree of latitude			One degree of longitude		
	sm	nm	km	sm	nm	km
Equator (0°)	68.71	59.71	110.57	69.17	60.11	111.32
10°	68.73	59.72	110.61	68.13	59.20	109.64
20°	68.79	59.78	110.70	65.02	56.50	104.65
30°	68.88	59.86	110.85	59.95	52.10	96.49
40°	68.99	59.95	111.04	53.06	46.11	85.39
50°	69.11	60.06	111.23	44.55	38.71	71.70
60°	69.23	60.16	111.41	34.67	30.13	55.80
70°	69.32	60.24	111.56	23.73	20.62	38.19
80°	69.38	60.29	111.66	12.05	10.47	19.39
Poles (90°)	69.40	60.31	111.69	0	0	0

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

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