2014년도 추계학술대회 논문집 pp. 114~116

Interpolation method for the missing AIS dynamic Data of Ship

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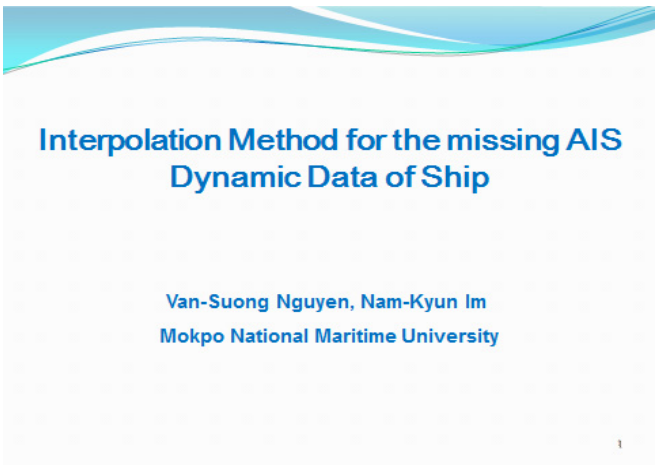
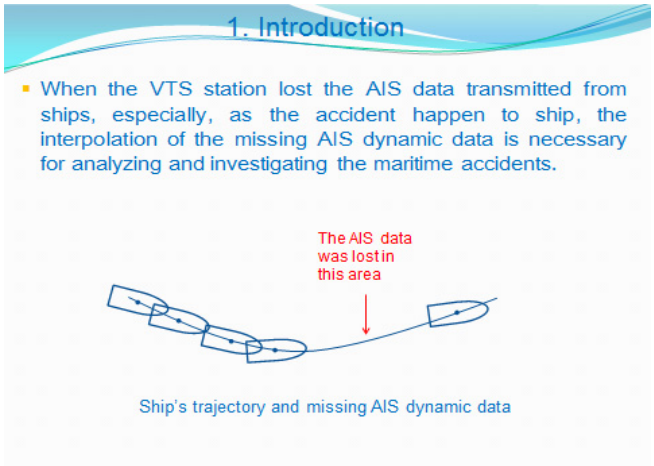
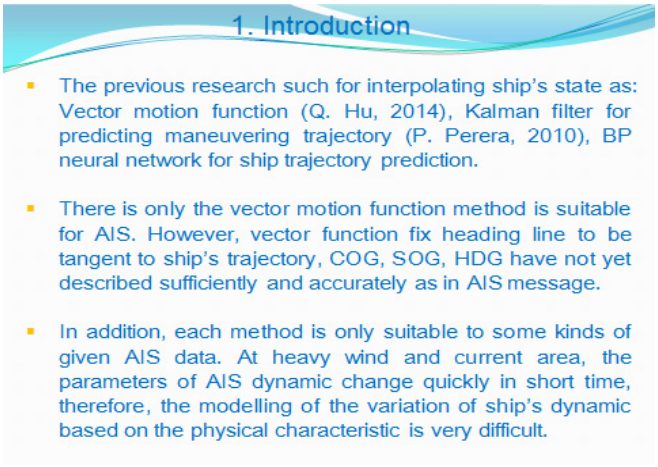
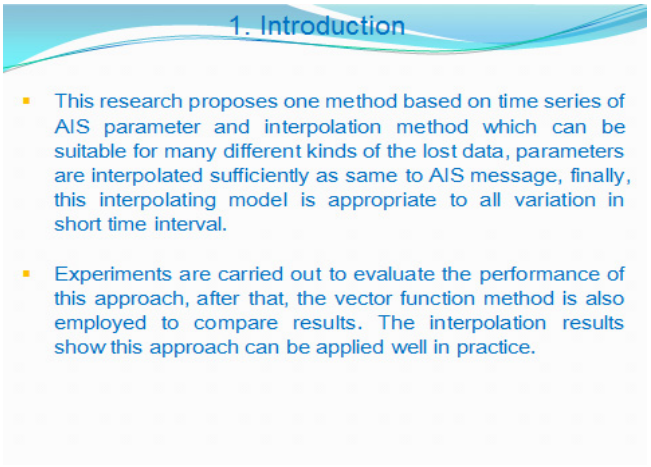
Abstract: *The interpolation of the missing AIS dynamic data can be used for predicting the lost data of the ship's state which is able to product the valuable information for analyzing and investigating the maritime accidents. The previous research proposed some interpolating methods however there exists some problem, firstly, the interpolated parameters such as COG, SOG, HDG weren't described sufficiently and accurately as in AIS message, secondly, each method is only suitable to some kinds of given AIS data, finally at heavy wind and current area, the parameters of AIS dynamic change quickly in short time, therefore, the modelling of the variation of ship's dynamic based on the physical characteristic is very difficult, in these cases the time-series and numerical method are usually better. This research proposes the other method through numerical analysis which can be suitable for many different kinds of the lost data, parameters are interpolated sufficiently, beside that this model is appropriate to all variation in short time interval. All the given AIS dynamic are regarded as the functions to time, then curves are established for fitting all data. Experiments are carried out to evaluate the performance of this approach, the interpolation results show this approach can be applied well in practice.*

Key words : *AIS dynamic information, maritime accidence, numerical analysis, ship movement, VTS station.*









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2. The components of AIS message

- The AIS data are divided into the static, dynamic information and relative information.

The static information

The dynamic information

The relative information

2. The components of AIS message

- As the regulation, the static information should be transmitted every 6 minutes and on demand, the dynamic information should be in time intervals from 2 to 10 seconds depending on ship's speed.

Class A	Transmitting a signal when on a steady course	Transmitting a signal when turning
SOG<0.2 knots	every 180 seconds	every 180 seconds
0.2 knots <= SOG < 14 knots	every 10 seconds	every 3.33 seconds
14 knots <= SOG < 23 knots	every 6 seconds	every 2 seconds
SOG >=23 knots	every 2 seconds	every 2 seconds

- This research, the dynamic information as: ship position, COG, SOG, HDG are considered for solving the missing AIS data.

3. Numerical methods for interpolating

- All of the ship's dynamic parameters in the AIS message are divided into time series, i time samples as follows.

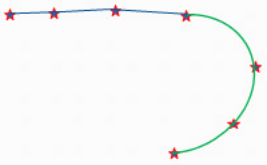
$$(t_i; lat(t_i)); (t_i; long(t_i)); (t_i; COG(t_i)); (t_i; SOG(t_i)); (t_i; HDG(t_i))$$

$$f(t_i) = [lat(t_i); long(t_i); COG(t_i); SOG(t_i); HDG(t_i)]$$

Where: $f(t_i)$ is common symbol for parameters of AIS data

- This research proposes 3 methods for interpolation problem
  - Piecewise linear Interpolation
  - Spline Function Interpolation
  - Piecewise Cubic Hermit Interpolation

3. Numerical methods for interpolating



★ : given data of time series in AIS dynamic

— : fitting by Piecewise linear Interpolation

— : fitting by Spline or Piecewise Cubic Hermit Interpolation

- Piecewise linear Interpolation is appropriate to shape of straight line of time-series data. It is used for steady course.
- Spline or Piecewise Cubic Hermit Interpolation are more accurate for curve shape of time-series data. They are applied for turning course.

3. Numerical methods for interpolating

- Piecewise Cubic Hermit Interpolation

A Spline Cubic Interpolation in time interval $[t_i; t_{i+1}]$

$$P(t) = f_i H_1(t) + f_{i+1} H_2(t) + P'(t_i) H_3(t) + P'(t_{i+1}) H_4(t)$$

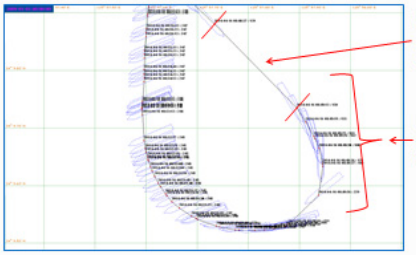
Where

$$H_1(t) = \phi\left(\frac{t_{i+1}-t_i}{h_i}\right),\ H_2(t) = \phi\left(\frac{t-t_i}{h_i}\right)$$
$$H_3(t) = -h_i\psi\left(\frac{t_{i+1}-t_i}{h_i}\right),\ H_4(t) = h_i\psi\left(\frac{t-t_i}{h_i}\right)$$
$$h_i = t_{i+1} - t_i,\ \phi(t) = 3t^2 - 2t^3$$
$$\psi(t) = t^3 - t^2$$

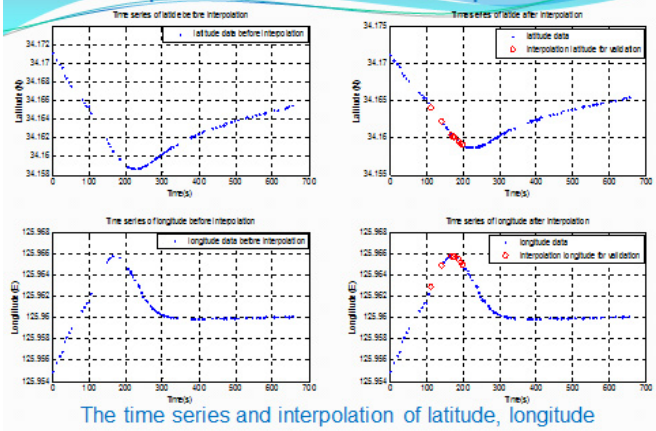
$\phi(t), \psi(t)$ are basic hermit function

4. Experiment and results comparison

- The real time data is collected from the Sewol passenger ferry of South Korea, she was sunk at JinDo island in 16/4/2014. In this research, we assume the time interval 08:48:37 AM to 08:50:16 AM, the AIS dynamic information was lost to validate this method, after that, the missing information will be suggested by this method.

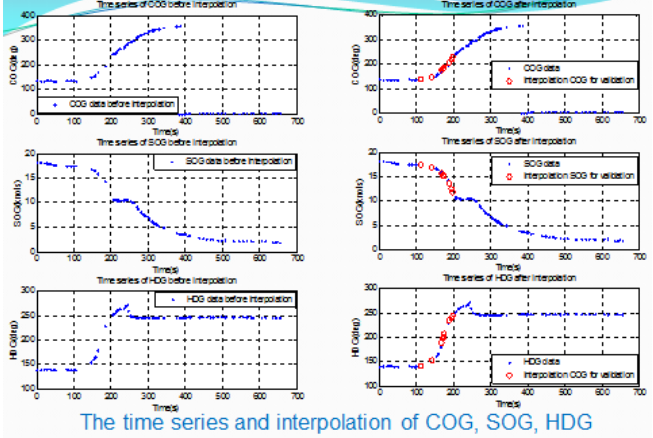


4. Experiment and results comparison



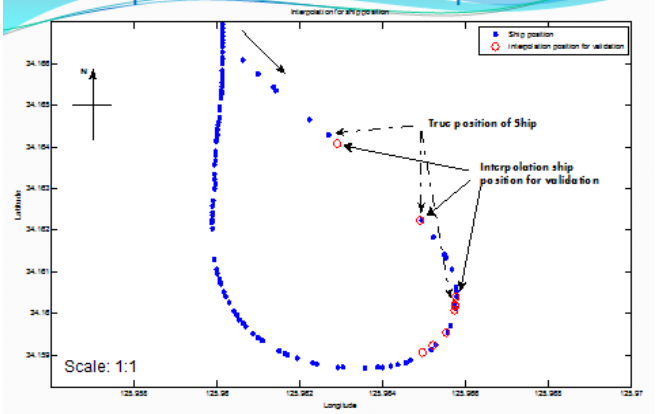
The time series and interpolation of latitude, longitude

4. Experiment and results comparison



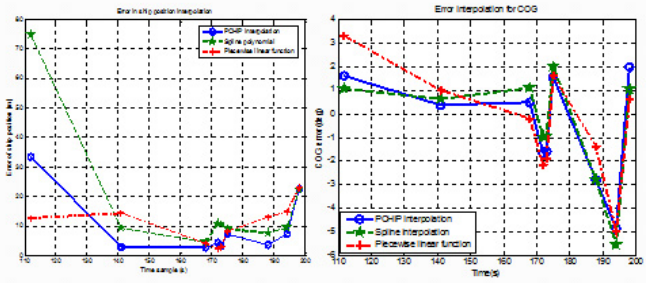
The time series and interpolation of COG, SOG, HDG

4. Experiment and results comparison



Interpolation for ship position

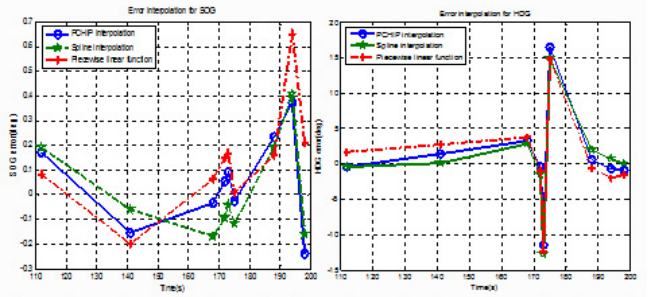
4. Experiment and results comparison



Error of ship positions interpolation

Error of COG interpolation

4. Experiment and results comparison



Error of SOG interpolation

Error of HDG interpolation

5. Conclusion

This research propose one method for interpolating the missing AIS data basing on the time series and numerical method

All parameters of AIS dynamic are interpolated sufficiently by this method

This method is suitable for all kinds of given AIS data, specially, the parameters of AIS dynamic change quickly in short time.

Experiments show that results of this method is better than other method in interpolating AIS data problem.