

해상교통류에 적용되는 확률 이론의 검증적 고찰

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요 약 : 해상교통안전진단제도의 시행으로, 해상교통에 영향을 미칠 가능성이 있는 모든 건설 사업은 필히 선박운항자 관점에서 그 안전성을 검토하여야 한다. 진단제도의 정량적 평가항목 중예, 선박이 장애물이나 위험지역과의 충돌확률을 평가하는 근접도 평가 항목이 있는데, 이는 항로상의 어떤 단면에서의 선박 궤적 분포가 정규 분포를 한다는 가정에 근거하고 있다. 한편, 진단제도의 또 하나의 정량적 평가기법중 하나인 해상교통류 시뮬레이션에서는, 대상 선박들의 예상 항차수로부터 선박을 통계적으로 발생시키는 기법을 사용하는데, 여기에서는 항로상의 특정 지점을 연속해서 통과하는 선박들의 시간 간격이 Poisson 분포를 따른다는 가정을 사용한다. 본 논문에서는 이러한 기본적인 가정들이 적합한지를 고찰하기 위하여, 광양 및 인천항에서 실측한 해상교통현황 조사 결과를 분석하였다.

핵심용어 : 해상교통안전진단, 해상교통류, 정규분포, Poisson 분포, 충돌확률

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introduction


- Any construction works that may influence maritime traffic safety should be **assessed by MSA**(Maritime Safety Audit).
- Two statistical assumptions are frequently used for quantitative assessment of maritime safety.
 - the distribution of ship trajectories at some cross section of fairway would follow **normal Gaussian distribution**
 - the distribution of time interval between two consecutive arrivals of vessels would follow **Poisson distribution**
- To verify these basic assumptions, maritime traffic survey results have been statistically analyzed.



3

contents


- introduction
- maritime traffic flow survey
 - Incheon Bridge
 - Kwang-Yang harbor
- basic theory and verification
 - normal distribution of traffic flow
 - Poisson distribution of traffic flow
- concluding remarks
- future works



2

maritime traffic flow survey

- maritime traffic flow survey is usually carried out to get idea about the general **maritime traffic status** around the target area where new construction plan is being established.
- two kinds of traffic survey
 - 72-hour on-site survey by using AIS receiver and portable radar
 - GICOMS(General Information Center On Maritime Safety) data
- recently, two surveys have been carried out
 - around Incheon Bridge (May 2~5, 2012)
 - around Kwang-Yang harbor (Apr 20~22, 2012)

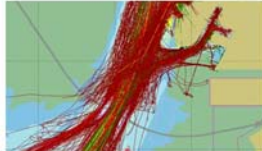
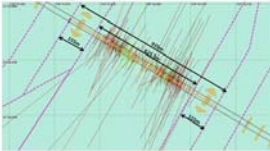


4

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traffic survey around Incheon Bridge

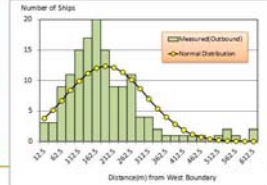
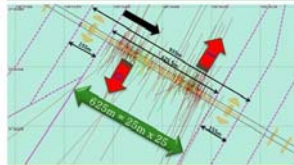
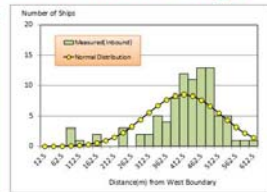
- traffic survey for 72 hours around Incheon Bridge
 - May 20 16:00 ~ 5 16:00, 2012
 - AIS and radar
 - all ships are included
- Fairway at Incheon Bridge
 - 625m wide
 - two-way traffic



5

normal distribution – Incheon Bridge

- 625m width = 25m x 25 segments
- the number of ships passing each segment has been counted from the maritime traffic survey results.
 - the passing direction (inbound and outbound) is considered



8

traffic survey around KY harbor

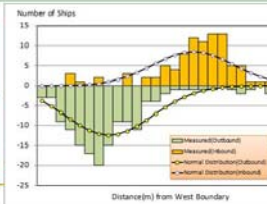
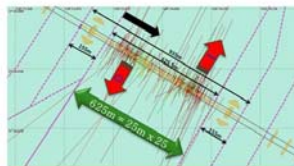
- traffic survey at KY harbor by GICOMS data
 - Apr. 20 00:00 ~ 22 24:00, 2012
 - ships equipped with AIS
 - small ships without AIS are excluded
- #3 & #4 Fairway (almost one-way)
 - #3 : inbound, 430m wide
 - #4 : outbound, 470m wide



6

normal distribution – Incheon Bridge

- typical patterns of two-way traffic fairway
 - major position of transit is not center line, but 1/4 and 3/4 position
- small traffic ships
 - moving in opposite direction, reason of relative poor agreement with normal distribution assumption.
- each distribution, however, seems to be in general agreement with the assumption of normal distribution.



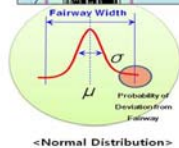
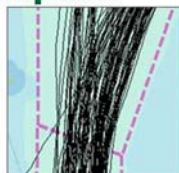
9

normal distribution assumption

- distribution of ship trajectories at some cross section of fairway would follow normal Gaussian distribution
- if mean position (μ) and standard deviation (σ) are known, the probability density function of ship position across fairway can be expressed as

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

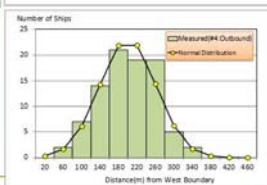
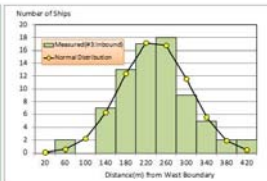
- based on this assumption, it becomes possible to estimate the probability that ships may exceed fairway boundary



7

normal distribution – KY harbor

- one-way fairway
 - #3 (430m) = 40m x 11 segments
 - #4 (470m) = 40m x 12 segments
- typical patterns of one-way traffic
 - transit position is almost center
- AIS equipped vessels only
 - relative good agreement with normal distribution

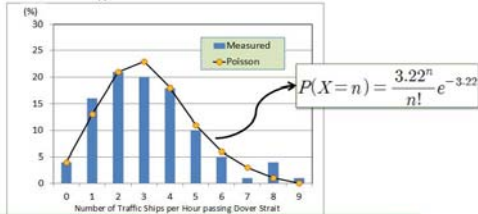


10

Poisson distribution assumption

- The number of ships (n) passing some position of fairway for some time interval (Δt) is known to follow Poisson distribution

$$P(X=n) = \frac{(\lambda \cdot \Delta t)^n}{n!} e^{-\lambda \cdot \Delta t} \quad n = 0, 1, 2, \dots$$



Distribution of number of traffic ships per hour at Dover Strait
($\lambda \Delta t = \text{mean number of traffic ships} = 3.22$)

11

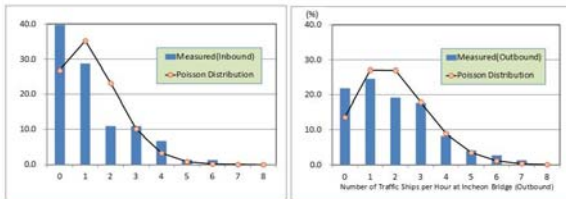
concluding remarks

- two kinds of statistical assumptions have been reviewed and tested with real traffic survey data
- normal distribution of ship trajectories**
 - tested for one-way and two-way fairways
 - one way traffic with relatively large vessels: the agreement between measurement and prediction is good.
 - two way traffic including relatively small vessels: the agreement tends to be poor.
 - the basic assumption of normal distribution, however, seems to be practically reasonable**
- Poisson distribution of the number of arriving ships**
 - the agreement between measurement and prediction is generally good** regardless of one or two-way traffic or vessel sizes involved in the analysis.
 - the agreement tendency seems to be increasing as the number of measuring time increases

14

Poisson distribution – Incheon Bridge

- traffic ships around Incheon Bridge for 72 hours
 - Inbound 92 ships (mean = 1.315 ships / hour)
 - Outbound 143 ships (mean = 1.994 ships / hour)
- general agreement between measured data and predicted data based on Poisson distribution assumption.



12

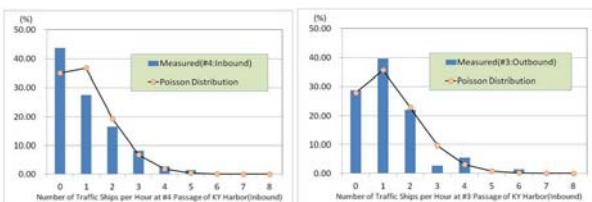
future plan

- this kind of statistical verification needs to be carried out further for various types of fairways and maritime traffic patterns
- the sensitivity analysis depending on the segment size, vessel sizes involved, and the size of population need to be carried out

15

Poisson distribution – KY harbor

- traffic ships at #3 and #4 passage of Kwang-Yang harbor for 72 hours
 - #3(Inbound) 75 ships (mean = 1.051 ships / hour)
 - #4(Outbound) 89 ships (mean = 1.277 ships / hour)
- general agreement between measured data and predicted data based on Poisson distribution assumption.



13