SHIP MANOEUVRABILITY, CONTROL AND NAVIGATIONAL SAFETY

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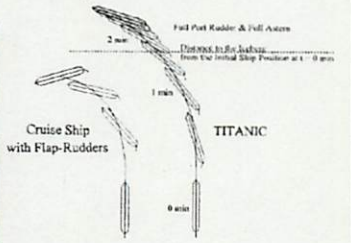
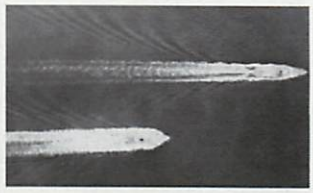
Condolence on Haruzo Eda (1926-2010)



Condolence on Takao Inui (1920-2012)



Who are we?

- To answer to this question is not only the one of the tasks but *the* task of science.

- Edwin Schrödinger (1987-1961)

Sea

- (Hindi) Samudra
- (Chinese and Japanese)
  海 sea and 母 mother
- (French) Mère and Mer

Technology

- (Hindi) ?
- (Greek) Τεχνη
- (Chinese and Japanese)

heaven

ground

Philosophy vs. Science

- (Greek) "Philo" (love) + "sophia" (wisdom) = Love and pursuit of wisdom by intellectual and moral self-discipline
- (Latin) "Scientia" (know) <- scire (cut)
- Akira Takamatsu (11 year-old boy): It starts always from one "why"?

"Know" vs. "Understand"

- "I know it" vs. "I understand it"
- We need philosophy to understand science and technology
- (tips) B.Sc. vs. B.Tech.

Manoeuvrability

- "Manoeuvre" + "ability"
- <- "mano" = hand

Control

- (Latine) Contrarotulus = "Contra" + "roll" = rotate reverse

Conclusions

- We love science and technology
- We want to know it and understand it
- For this purpose we need philosophy
- We proud of our research and education field related to the sea, mother of all lives. We still keep our memory of the time we were in the sea, when we are in the sea (amnion liquid) of the belly (matrix) of our mothers.
- You (sea) are in our mother (in French) and our mother is in you (in Chinese and Japanese).

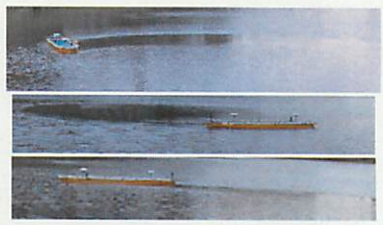
Is it science or philosophy?

Ship Manouvrability in 1970s

Ship Manoeuvring Model before 1970

- David and Schiff Model
  - Davidson, K.S.M., and L.I. Schiff, Turning and course keeping qualities, Trans. SNAME, Vol.54, 1946
- Abkowitz Model
  - Abkowitz, M.A., Lectures on Ship Hydrodynamics - Steering and Manoeuvrability, Hya Report no. Hy-5, 1964
- Nomoto's K-T Model
  - First order Model
  - Second order model
  - Second order non-linear model
- Necessity to develop a model for new types of ships

Model Ship Experiments



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Background and History of the Research

- Ship manoeuvring research in 1970s
- Autopilot for saving energy
- Necessity of the research of man-machine System
  - Developing a ship handling simulator, as one of the oldest ones in the world
- Developing standard mathematical model of ship manoeuvring

Adaptive Autopilot

- Model Reference Adaptive Control
  - Amerongen, J. van and A.J. Udink ten Cate, Model reference adaptive autopilots for ships, Automatica, Vol. 11., pp.441-449, 1975
- Self-tuning Control
  - Kallstrom, C.G., K.J. Åström, N.E. Thorell, J. Eriksson and L. Sten, Adaptive autopilots for steering of large tankers, Report Department of Automatic Control, Lund Institute of Technology, Lund , Sweden, 1977
- Stochastic Model
  - Otsu, K., M. Horigome, G. Kitagawa, A new ships autopilot design through a stochastic model, Automatica, Vol 15, pp. 255-268, 1979
- Adaptive Control
  - Tiano, A., E. Volta, A.W. Brink and T.W. Verbruggen, Adaptive control of large ships in non-stationary conditions - a simulation study, Proceedings Symposium on Ship Steering Automatic Control, Genova, Italy, 1980
- etc

Cost Function of Fuel Consumption

- Koyama's criterion $J=\int(z^2+\lambda\delta^2)dt$
  - Koyama, T. On the optimum automatic steering system of ships at sea, J.S.N.A., Vol. 122, Dec., 1967
- Norrbin, N.H., On the added resistance due to steering on a straight course, 13th ITTC,Berlin, Hamburg, 1972
- Clarke, D., Development of a cost function for autopilot optimization, Proceedings Symposium on Ship Steering Automatic Control, Genova, Italy, 1980
- Blacke, M., and J.C. Norloff-Thompson, Experiment with direct measurement of steering generated propulsion losses, 6th Ship Control Systems Symposium, Ottawa, Canada, 1981
- Hasegawa's criterion
  - K. Hasegawa : On a Performance Criterion of Autopilot Navigation, Journal of the Kansai Society of Naval Architects, Japan (J.KSNAJ) 178, pp.93-103, Sep., 1980
- etc

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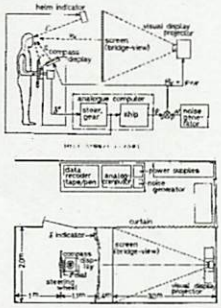
Dec. 7, 1972

40th Anniversary of Apollo 17 launching

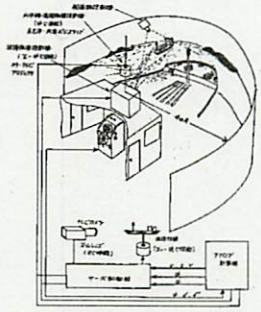
First Generation Ship Handling Simulator (1974)

- Feasibility study on instability criterion of human ability to control a VLCC (SR151, Japan)
  - Nomoto, K., Simulators from the naval architects point of view, Proceedings of MARSIM, Southampton, UK, 1978
  - T. Koyama, K. Kose and K. Hasegawa : A Study on the Instability Criterion of the Manual Steering of Ships (in Japanese), J. of the Society of Naval Architects of Japan (J.SNAJ) 142, pp.119-126, Dec., 1977

First Ship Handling Simulator in the world (Hiroshima University, 1970)



SR151 Ship Handling Simulator (1974)



Intelligent Ship Handling Simulator (2010)

- World first intelligent ship handling simulator was installed on a ship handling simulator at NMRI (National Maritime Research Institute), Tokyo as a cooperative work with Osaka University and NMRI.
- To be presented at the spring meeting of JIN (Japanese Institute of Navigation) at Kobe, May 2011.

Intelligent Ship Handling Simulator

Reproduction of an accident

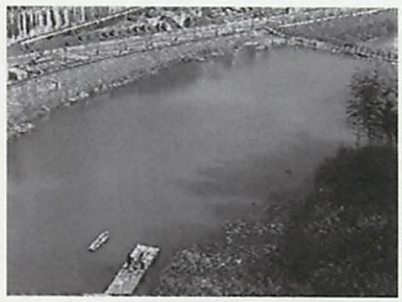
Background and History of the Research (contin'd)

- Developing intelligent ship control systems including
  - collision avoidance
  - berthing/deberthing control
- Developing a tool for safety assessment in congested waterways
- Developing standardisation of mathematical model of ship manoeuvring in low speed and/ or in shallow water etc

Automatic Collision Avoidance

- Fuzzy Reasoning and Control
  - A. Kouzuki and K. Hasegawa : Automatic Collision Avoidance System for Ships Using fuzzy Control (in Japanese). J.KSNAJ 205, pp.1-10, June 1987
  - K. Hasegawa : Fuzzy Modelling of the Behaviours and Decision-Making of Ship Navigators, Proc. of 3rd International Fuzzy Systems Association (IFSA)Congress, pp.663-666, Seattle, Aug. 1989
- Expert System for Multiple Ship Encounter
  - K. Hasegawa, A. Kouzuki, T. Muramatsu, H. Komine and Y. Watabe : Ship Auto-navigation Fuzzy Expert System (SAFES) (in Japanese), J.SNAJ 166, pp.445-452, Dec. 1989

Automatic Collision Avoidance Experiment



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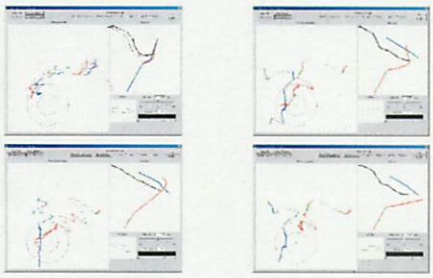

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Automatic Berthing Experiment

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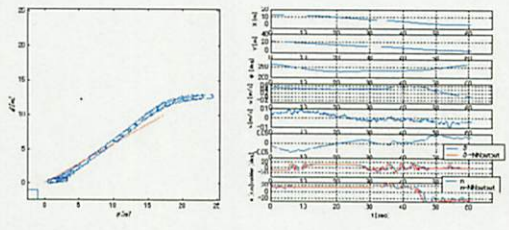

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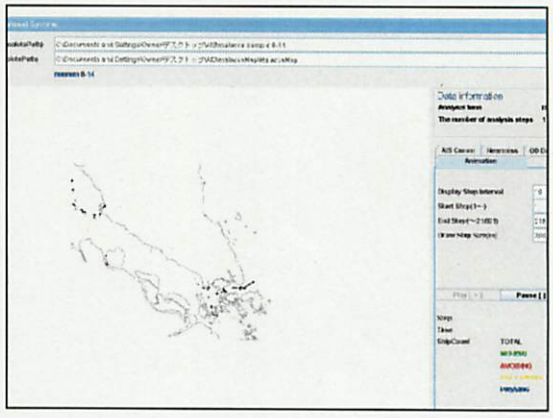

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Single-propeller Twin-Rudder Ship

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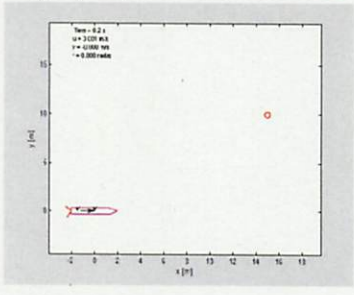
Automatic Navigation in Slow Speed by Single-propeller Twin-rudder Ship



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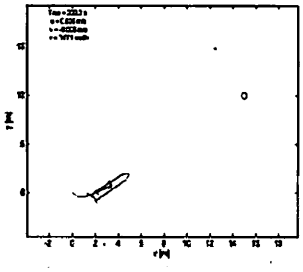

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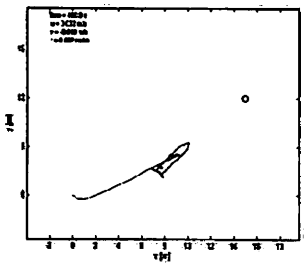

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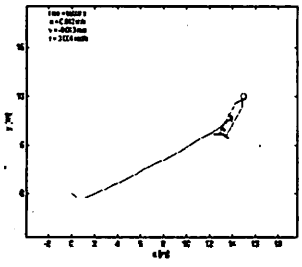

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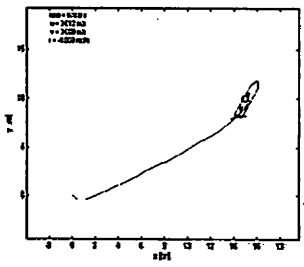

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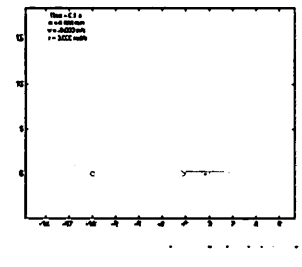
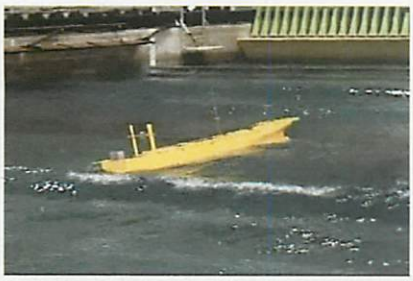


Concluding Remarks

- Ship manoeuvrability and its prediction are long-time subject.
- It cannot be separated with human and autopilot behaviours and with environmental disturbances.
- New devises, new theories and new ideas to overcome these important issues are highly recommended to be searched by younger generation.

Capsizing Experiment
(by Profs. Umeda and Hashimoto)



Capsizing Experiment
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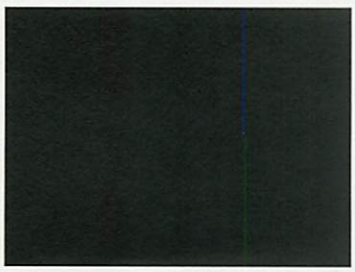
Arbitrary Wave Generator
(by Profs. Naito and Minoura, Osaka University)



Squid Robot
(by Prof. Toda, Osaka University)

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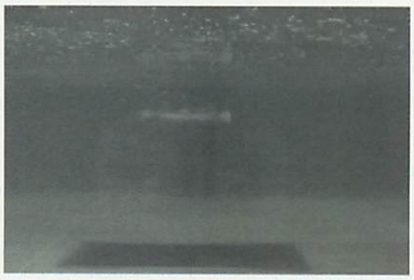

Thank you for your attention and

You are always welcome to come to Japan