論文の内容の要旨

論文題目　Analysis of Data-Driven Inverse Problems in Marine Engineering Based on Stochastic Inverse Theory
（確率逆問題論の海洋工学への適用に関する研究）

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In almost all scientific and engineering applications, it is sometimes necessary to infer some properties characterizing a physical system of interests. These parameters are often inaccessible or unobservable by direct measurements. This problem area studying inverse procedures to infer unknown physical properties from observed measurements is called inverse problems. The related theory is generally connected with optimization problems that lead to indirect measurement in engineering fields.

The main objective of this thesis is on the study of data-driven inverse problems, which handle actual noisy measurements, in marine engineering based on the stochastic inverse theory that has been attracting much research interest lately in various applied fields, especially related to the robust and reliable solution framework for inverse problems.

In this thesis work, attentions are mainly focused on the development of robust and reliable analysis tools that can be applicable to marine engineering problems, more specifically, the problems of

- Indirect measurements of physical sources that makes fluid motions,
- Identification of nonlinear systems for marine structures,
- Estimation of wave force acting on marine structural systems.

The first step in achieving this objective is to derive the inverse framework, which explicitly specifies the dependence of observable and unobservable parameters. In this work, the stochastic inverse theory is utilized to construct stochastic inverse frameworks. The advantages of using the stochastic inverse theory are that indirect measurement problems can be easily derived, and the reliability analysis on the estimated solution is also possible.

Each subject listed above has also its own distinctive improvements compared with

many other existing methods. Extensive literature reviews and detailed explanations on this fact are also described separately in each chapter. For each subject, reliable and robust analysis tools are proposed with special emphasis on the following four issues:

- Construction of a system model which determines the dependence between observable measurements and desired physical properties,
- Formulation of a stochastic inverse problem which allows to infer the desired condition or the cause of the observed effect,
- Specification of solution of the stochastic inverse problem through probabilistic modeling which enables quantification of the uncertainty in the inverse solution,
- Computation of stochastic inverse solutions by using Markov chain Monte Carlo algorithm with full probabilistic description.

This thesis is divided into 2 parts and 6 chapters. In the first part, Chapters 2-3, stochastic inverse theory and its applications to marine hydrodynamics are presented. Chapter 2 is on an overview of the stochastic inverse theory. First of all, fundamentals for understanding the concept of inverse problems are reviewed. A brief description on the stochastic inverse framework and necessary backgrounds is then presented for understanding materials presented in subsequent chapters. Chapter 3 contains applications of stochastic inverse theory to marine hydrodynamics with special emphasis on the discussion about construction and distinctive features of the stochastic inverse framework.

The second part, Chapters 4-6, is focused on two stochastic estimation problems of nonlinear systems: stochastic inverse modeling and identification of nonlinear system, and stochastic estimation of external force acting on nonlinear system. In Chapter 4, a new non-parametric and stochastic method is presented for identifying nonlinear system. The characteristic of the proposed method is first theoretically and numerically investigated with nonlinear oscillator models. In Chapter 5, the practicability of the proposed methods is verified by experimental works with regards to ship rolling motion. In Chapter 6, a stochastic estimation method is proposed for estimating external force acting on nonlinear dynamical system from observed response data. The characteristic of the proposed method is also thoroughly examined and then applied to laboratory tests regarding fluid-structure interaction.

Finally, conclusions are made in Chapter 7 with suggestions for future study. A summary of findings and limitations of the present analysis method are also presented. This thesis may provide some new insights into the study involved in data-driven inverse problems in marine engineering. Furthermore, the proposed methods are believed to be useful for many practical applications regarding estimation of nonlinear systems.