



# HOKKAIDO UNIVERSITY

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## 学 位 論 文 内 容 の 要 旨

### DISSERTATION ABSTRACT

博士の専攻分野の名称 博士（工学） 氏名 Bennie Hamunzala

## 学 位 論 文 題 名

Title of dissertation submitted for the degree

### DEVELOPMENT OF AN IMPROVED SATELLITE IMAGERY METHOD FOR ESTIMATING THE CONSTRUCTION YEARS OF ROAD BRIDGES

(道路橋の建設年を推定するための改良された衛星画像解析手法の開発)

Effective management of bridge infrastructure is crucial for ensuring safety and longevity with limited resources. This study proposes an improved method for estimating construction years of road bridges using remote sensing and statistical analysis techniques. The use of bridge age and damage ratings is a cost-effective approach for evaluating the deterioration rates and predicting the future physical conditions of road bridges. Bridge authorities and organizations can benefit from this method, enabling them to prioritize maintenance and repairs effectively. The purpose of this study is to develop a clear and objective method for estimating construction years of road bridges, addressing the limitations of previous research.

The study aims to provide a reliable tool for bridge authorities and organizations to manage bridge infrastructure effectively. The method's accuracy and reliability are crucial for informing maintenance and repair decisions. The study utilizes the remote sensing data, the Normalized Difference Water Index 2 (NDWI<sub>2</sub>), from Landsat 5 Thematic Mapper and Landsat 7 Enhanced Thematic Mapper Plus. Google Earth Engine (GEE) processes and analyzes the NDWI<sub>2</sub>. The Sequential T-test Analysis of Regime Shift (STARS) method identifies the estimated construction year from the analyzed NDWI<sub>2</sub>. The NDWI<sub>2</sub> is a function of near-infrared (NIR), and shortwave infrared 2 (SWIR<sub>2</sub>) bands, mathematically expressed as:  $NDWI_2 = (NIR - SWIR_2) / (NIR + SWIR_2)$ .

The performance of the method was tested in Nago City, Japan, Cambodia, and Zambia. The results show promising accuracy, with correctly estimated construction years for road bridges in Nago City, Cambodia, and Zambia. The regression analysis yielded  $R^2$  values of 0.33, 0.06, and 0.64 for the bridges in Nago City, Japan, Cambodia, and Zambia, respectively. The absolute mean errors determined were 2.69, 4.93, and 13.79 for the bridges in Nago City, Cambodia, and Zambia, respectively. The estimated number of correctly identified bridges with estimated construction years in Nago City were 39 out of 44 road bridges, 423 out of 649 road bridges in Cambodia, and 14 out of 27 in Zambia. The study's findings demonstrate the potential of remote sensing and statistical analysis techniques in accurately estimating the construction years of road bridges. The relatively low  $R^2$  values may be attributed to insufficient reflectance due to atmospheric absorption and scattering effects. In addition, differences between the planned year of construction recorded in the database and the actual year of

construction may have contributed to the discrepancy between the estimated construction years and actual construction years, resulting in lower  $R^2$  values. Such discrepancies may have been caused by construction delays. The limited number of road bridges tested in Zambia was due to the insufficient availability of road bridge data with known years of construction.

The improved method offers significant time and cost savings, particularly for road bridges with unknown construction years. It also serves as a valuable planning tool for bridge maintenance and improvement. The methodology holds promise beyond road bridges, extending to the determination of construction years for other structures. The study's contributions include the development of an objective and clear method for estimating the construction years, the demonstration of the method's accuracy and reliability, and the potential for broader applications in infrastructure management.

The method's objectivity and clarity make it a valuable tool for bridge authorities and organizations. Future studies can build on this research to improve the accuracy and reliability of construction year estimates. The study's findings have implications for infrastructure management, highlighting the importance of accurate construction year estimates for effective maintenance and repair decisions.