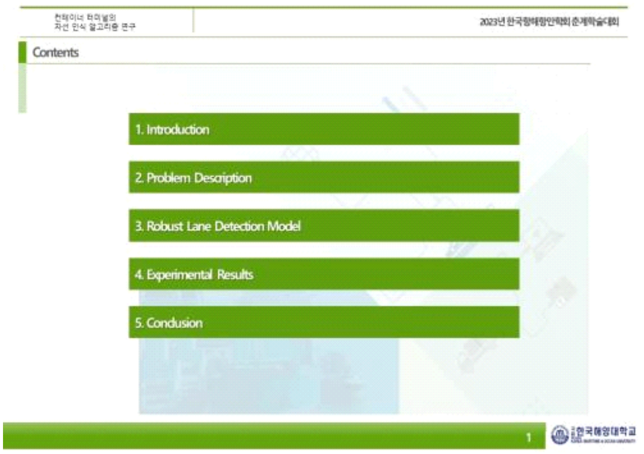
Robust Lane Detection Algorithm for Autonomous Trucks in Container Terminal

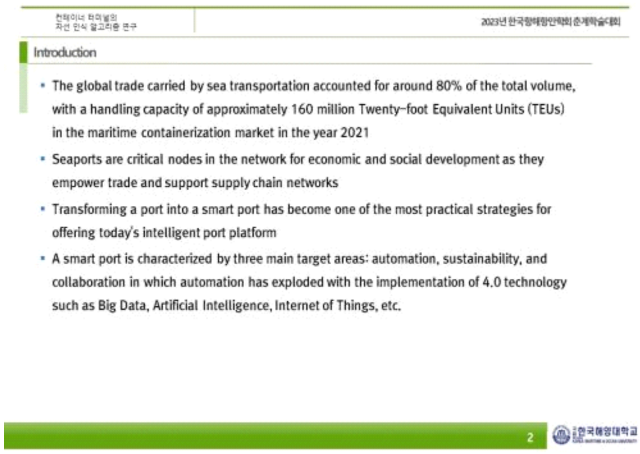
Ngo Quang Vinh · Sam-Sang You** · Le Ngoc Bao Long*** · † Hwan-Seong Kim*

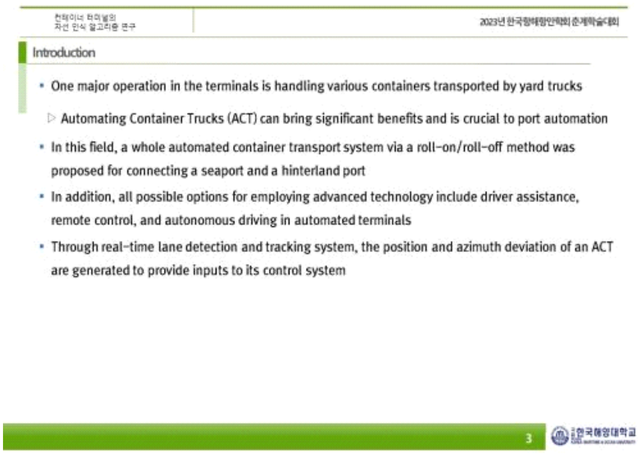
**M.S. Course, Graduate school of Korea Maritime and Ocean University, Busan, 49112, KOREA*
***Professor, Division of Mechanical Engineering, Korea Maritime and Ocean University, Busan, 49112, KOREA*
****PhD. Course, Graduate school of Korea Maritime and Ocean University, Busan, 49112, KOREA*
† Professor, Dept. of Logistics, Korea Maritime and Ocean University, Busan, 49112, KOREA

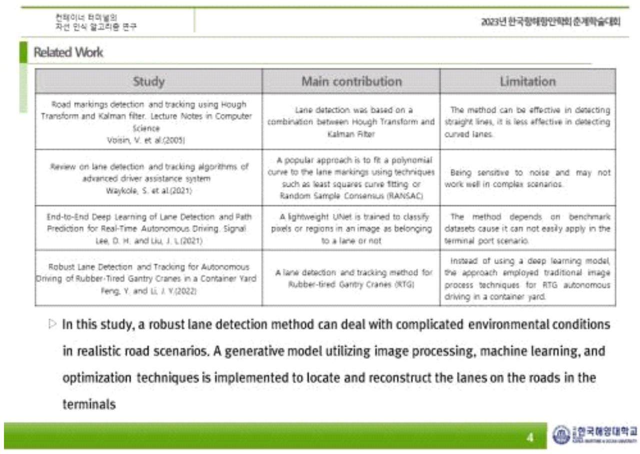
Abstract : *Container terminal automation might offer many potential benefits, such as increased productivity, reduced cost, and improved safety. Autonomous trucks can lead to more efficient container transport. A robust lane detection method is proposed using score-based generative modeling through stochastic differential equations for image-to-image translation. Image processing techniques are combined with Density-Based Spatial Clustering of Applications with Noise (DBSCAN) and Genetic Algorithm (GA) to ensure lane positioning robustness. The proposed method is validated by a dataset collected from the port terminals under different environmental conditions and tested the robustness of the lane detection method with stochastic noise.*

Key words : *Container Terminal; Lane Detection; Image Processing; Stochastic Differential Equation, Deep Learning*









† Corresponding Author : 종신회원, kimhs@kmou.ac.kr 051)410-4334

Problem Description

- **The current terminal port scenario**
  - Figure 1 illustrates the practical scenario of the lanes on the road conditions in various environments
  - Facilities have been constructed for port operations over the years, and the degradation is evident in the infrastructures, and maintenance activities rarely occur at the terminals
  - Therefore, it is essential to reconstruct the lanes and roads on the monitor screen of the container trucks to assist the driver or to support the remote control system of ACT operations. Autonomous trucks must perform flawlessly in realistic road scenarios (sunny, rainy, smog, etc.) in any climate.

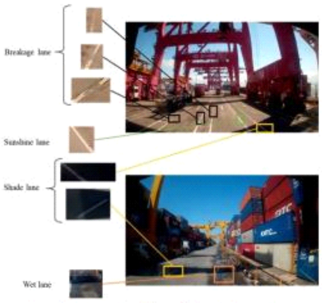


Fig 1. Environmental conditions of lanes on the roads in a container port (breakage, sunshine, shade, wet lane, etc.)

5

컨테이너 터미널의
차선 인식 알고리즘 연구
2023년 한국항해항만학회 춘계학술대회

Robust Lane Detection Model

- **Transforming image**
  - The whole process of the lane detection model contains two main stages: pre-processing and lane positioning
  - In image pre-processing, the model should deal with various environmental conditions of terminal images
  - A Score-based Generative Modeling with Differential Equation (SGMDE) is used to transfer bad images to better images to enhance the accuracy of the lane detection model
  - The SGMDE is the generative model which is developed to transfer image-to-image through two processes: a forward process (data-to-noise) and a reverse process (noise-to-data)

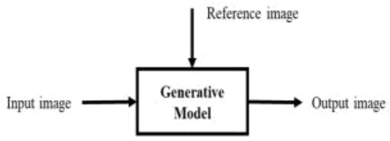


Fig 2. The primary idea of the generative model

6

컨테이너 터미널의
차선 인식 알고리즘 연구
2023년 한국항해항만학회 춘계학술대회

Robust Lane Detection Model

- **Transforming image**
  - A stochastic differential equation is employed to inject noises into images in each iteration, moving from x_0 to x_T. As illustrated in Figure 3, x_0 corresponds to a complex data distribution sampled from the original data distribution and x_T describes purely noises. x_T will eventually be an isotropic Gaussian distribution
  - In the reverse process, a stochastic differential equation transforms prior distribution back into data distribution by removing noises, moving from x_T to x_0

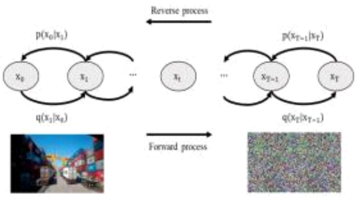


Fig 3. Illustration of the general diffusion process

7

컨테이너 터미널의
차선 인식 알고리즘 연구
2023년 한국항해항만학회 춘계학술대회

Robust Lane Detection Model

- **Transforming image**
  - The experiment result of the pre-processing stage

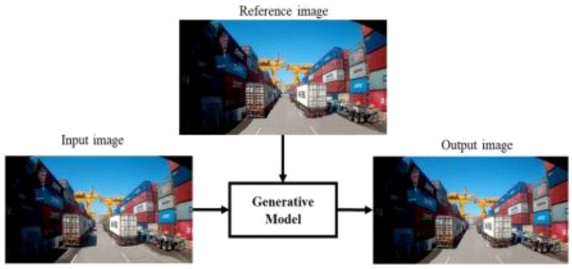


Fig 4. Test result of the pre-processing image stage

8

컨테이너 터미널의
차선 인식 알고리즘 연구
2023년 한국항해항만학회 춘계학술대회

Robust Lane Detection Model

- **Lane positioning**
  - The lane positioning accuracy can be improved by utilizing a color-based comparison principle and extracting a Region of Interest (RoI) in the image that focuses on the lane area while disregarding areas outside the lane
  - A sliding value of the image method is then employed to enhance the accuracy of straight-line detection. Afterward, noise-removing models, such as DBSCAN and GA, are utilized to determine lane positioning. Figure 5 shows the flowchart demonstrating vision-based lane positioning

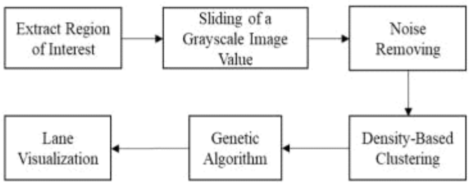


Fig 5. Diagram of the lane positioning process

9

컨테이너 터미널의
차선 인식 알고리즘 연구
2023년 한국항해항만학회 춘계학술대회

Robust Lane Detection Model

- **Extracting the region of interest and slide of a grayscale image**
  - The transformed image is employed to extract the area where the lane locates from an original image to reduce the interference of the background environment and improve the detection efficiency
  - To meet this requirement, the lane lines must remain within the RoI image, even as the distance between lanes changes during operation in the terminal port
  - The RoI is narrowed down to focus primarily on the lanes
  - This is followed by the conversion of the resulting cut-off image to grayscale format, ant the test results are presented in Figure 6

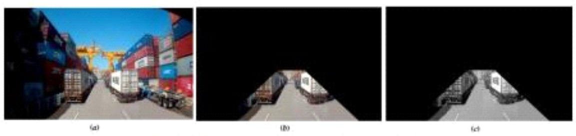


Fig 6. The first process of the lane positioning method
(a) Input image (b) Extracted RoI (c) Grayscale conversion

10