RTGC Non linear Control System Based on Sliding Mode Controller

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*Abstract*— The high traffic of containers between countries and continents demands the implementation of automation at cargo sea ports. Rubber Tyred Gantry Crane (RTGC) is one of the main components for loading and unloading at container yards. This paper attempts to examine non-linear control using the sliding mode controller (SMC) method for MIMO control problems in RTGC. The control objective is to reduce the swing angle and move the container to the desired position and height. The results obtained show that the SMC can provide satisfactory control performance even at various initial conditions and system parameters.

Keywords—Non linear control, sliding mode control, RTGC, MIMO, port automation)

# Introduction

In the midst of the development of transportation technology between countries and continents, the mode of cargo transportation is still very dependent on sea transportation. This is evidenced by [1] which states that 80% of cargo shipments still use sea transportation in Latin America. In the world, the volume of cargo traffic in 2021 is 840 million TEU, increasing 4 times since 2000 [2]. In Indonesia alone, the Tanjung Periok Port for cargo processing must operate 24 hours to handle the loading and unloading of containers [3]. Rubber Tyred Gantry Crane (RTGC) is one of the heavy equipment at seaports whose job is to load and unload containers at container yards. However, manual loading and unloading work by human operators is prone to accidents due to fatigue, or the lack of experience of loading and unloading operators, therefore the automation of the Rubber Tyred Gantry Crane (RTGC) needs to be improved.

In the case of RTGC automation, researchers generally study the problem of position control and swing angle on RTGC. Fuzzy-PID based control has been studied by [4] to reduce the swing angle. infinite H-based robust control - PID has also succeeded in reducing the swing angle even though the mass and length of the rope varies [5]. Time-optimal open loop, Proportional Derivative (PD), and fuzzy methods are also applied by [6]-[8] for controlling position and swing angle. In addition, various optimization methods are also used to find optimal controllers such as Genetic Algorithm (GA), Simulated Annealing (SA) [9], and Particle Swarm Optimization (PSO) [10].

The papers above use the RTGC linear model, in this paper we try to examine control using the non-linear method, namely the Sliding Mode Controller (SMC) on the RTGC non-linear model. In addition, the object that is controlled is not only the position and swing angle, but also the length of the rope. SMC has the advantage of low sensitivity to plant parameter variations so that less precise modeling can still provide acceptable performance. SMC is known as a robust control method in the midst of disturbances and uncertainties [11].

SMC has been used in various fields such as wind energy conversion systems because it can handle parametric uncertainties and disturbances [12]. SMC is also used to stabilize UMV under DoS attacks [13]. In addition, SMC is also applied to control electro-hydraulic servo systems[14], boost converter control of PV systems[15], and stabilization of disturbed quadrotor unmanned aerial vehicles[16]. This paper tries to explore the application of SMC for under actuated MIMO control problems in RTGC systems where the input control is in the form of force on the position of the trolley and the length of the rope with the control objectives being the swing angle, position and length of the rope.

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