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Developement of Mechanisms for Safe Tip-Over of Model Cranes

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ABSTRACT

This project focuses on the development of a scale model luffing jib tower crane for the Crane Safety Research Center. A luffing jib tower crane is a modern design which is gaining popularity for its advantage in urban construction sites. Fig. 1 shows a diagram of the layout of this style of crane. The luffing motion gives them more versatility than traditional tower cranes and allows for the jib to be stowed vertically for a minimal footprint. These come with the trade-offs that they are more expensive and require more maintenance. Despite their increase in use, there has not been much research done on this style of crane when compared with standard tower cranes. This scale model is being designed with the goal of conducting research which can identify the parameters that lead to cranes tipping over and model the dynamics and control of luffing motion in modern cranes.

The design process began by establishing the scope of the problem this system is being developed for. This consists of determining its purpose, use case, and environment. The purpose of this crane is to provide hardware on which students and researchers can study dynamics and test out controls. As such, the crane should utilize common mechatronics components and software for ease of use and maintenance. This enables the crane to be used to study both luffing motion and tip over conditions. The crane will be used in experiments which will require it to move through its 3 axes of motion in a fixed position, as well as safely tip over and fall. In addition to this, other sensors may be needed to track the tip over angle and speed. This model will need to be designed for safe tip over in a small lab area. From these needs, an emphasis is placed on modularity, aesthetics, serviceability, and durability.

This novel use of a safe tip-over catch mechanical for scale crane models requires validation through testing. On a smaller prototype model multiple mechanisms will be implemented to lock the tower section vertically, catch the fall of the tower section, and collect sensor data on the tip-over behaviour. The three leading designs for this mechanism are a set of adjustable legs mounted to the base, a vertical pipe section, and a hooped basket to catch the tower at a specific angle (Fig.2). These mechanisms can be installed with a sensored gimbal to track the fall of the tower section. These versions will be systematically evaluated to select the best mechanism to be scaled up for the model crane.

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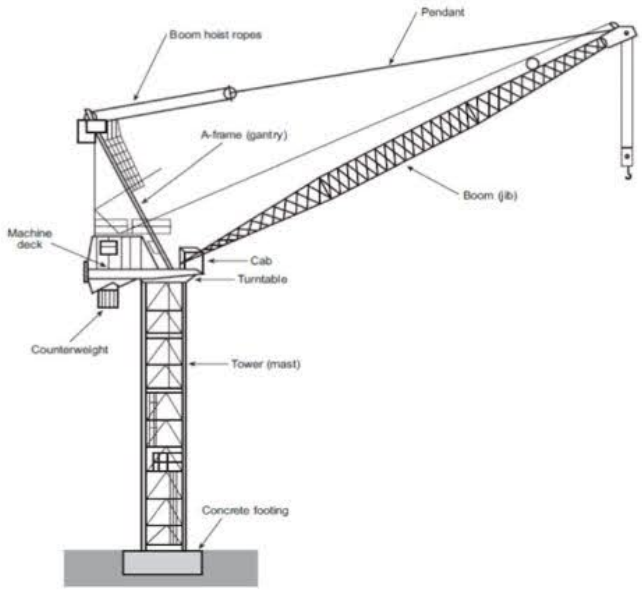

Fig. 1. Schematic Diagram of a Luffing Jib Tower Crane (image source: https://marcogroup.ca/a-unique-crane-on-the-skyline-of-halifax/)

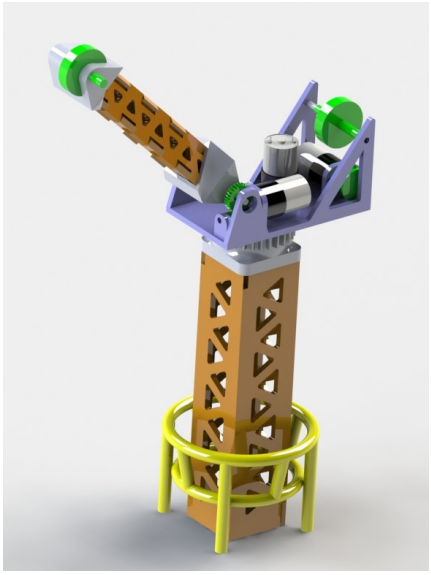

Fig. 2. CAD Model of Possible Catch Mechanism on Prototype Crane

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