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Measuring the Biomechanical Effects of Worker Skill Level and Joystick Crane Speed on Forestry Harvesting Performance Using a Simulator

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Abstract : The forest industry is a major economic sector of Canada and also one of the most dangerous industries for workers. The use of mechanized mobile forestry harvesting machines has successfully reduced the incidence of injuries in forest workers related to manual labor. However, these machines have also created additional concerns, including a high machine operation learning curve, increased the length of the workday, repetitive strain injury, cognitive load, physical and mental fatigue, and increased postural loads due to sitting in a confined space. It is critical to obtain objective performance data for employers to develop appropriate work practices for this industry, however ergonomic field studies of this industry are lacking mainly due to the difficulties in obtaining comprehensive data while operators are cutting trees in the woods. The purpose of this study was to establish a measurement and experimental protocol to examine the effects of worker skill level and movement training speed (joystick crane speed) on harvesting performance using a forestry simulator. A custom wrist angle measurement device was developed as part of the study to monitor Euler angles during operation of the simulator. The device of the system consisted of two accelerometers, a Bluetooth module, three 3V coin cells, a microcontroller, a voltage regulator and an application software. Harvesting performance and crane data was provided by the simulator software and included tree to frame collisions, crane to tree collisions, boom tip distance, number of trees cut, etc. A pilot study of 3 operators with various skill levels was tested to identify factors that distinguish highly skilled operators from novice or intermediate operators. Dependent variables such as reaction time, math skill, past work experience, training movement speed (e.g. joystick control speeds), harvesting experience level, muscle activity, and wrist biomechanics were measured and analyzed. A 10-channel wireless surface EMG system was used to monitor the amplitude and mean frequency of 10 upper extremity muscles during pre and postperformance on the forestry harvest stimulator. The results of the pilot study showed inconsistent changes in median frequency pre-and postoperation, but there was the increase in the activity of the flexor carpi radialis, anterior deltoid and upper trapezius of both arms. The wrist sensor results indicated that wrist supination and pronation occurred more than flexion and extension with radial-ulnar rotation demonstrating the least movement. Overall, wrist angular motion increased as the crane speed increased from slow to fast. Further data collection is needed and will help industry partners determine those factors that separate skill levels of operators, identify optimal training speeds, and determine the length of training required to bring new operators to an efficient skill level effectively. In addition to effective and employment training programs, results of this work will be used for selective employee recruitment strategies to improve employee retention after training. Further, improved training procedures and knowledge of the physical and mental demands on workers will lead to highly trained and efficient personnel, reduced risk of injury, and optimal work protocols.

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