Chapter 12
Design and Development of Teleoperation for Forest Machines: An Overview

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ABSTRACT

Teleoperation of forestry machinery is a difficult problem. The difficulties arise because forestry machines are primarily used in unstructured and uncontrolled environments. However, improvements in technology are making implementation of teleoperation for forestry machines feasible with off-the-shelf computing and networking hardware. The state-of-the-art in teleoperation of forestry machinery is reviewed as well as teleoperation in similarly unstructured and uncontrolled environments such as mining and underwater. Haptic feedback in a general sense is also reviewed, as while haptic feedback has been implemented on some types of heavy machinery it has not yet been implemented on forestry machinery.

1. INTRODUCTION

Teleoperation of forestry machinery is a difficult problem. Difficulties arise because forestry machines are primarily used in unstructured and uncontrolled environments. Improving technology is easing the difficulties and making teleoperation of forestry machines feasible with off-the-shelf computing and networking hardware.

Effective teleoperation in unstructured and uncontrolled environments requires sensing and modelling combined with a good operator.

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interface. Good feedback and controls creates *telepresence*, where an operator can operate a machine as well as if they were controlling it directly. Some types of feedback of interest include haptic (touch-force), orientation, audio, 3D mapping and binocular vision. Other unstructured and uncontrolled environments include mining (Hainsworth 2001), horticulture (Murakami, Ito et al. 2008; Billingsley, Oetomo et al. 2009), and aircraft control (Army UAS CoE Staff 2010; Pounds, Mahony et al. 2010).

Teleoperation may be thought of as an extension of remote control. Remote controlled systems are cheaper and easier to implement but are limited to situations where the operator can directly observe the machine. Effective remote control becomes difficult or impossible in conditions like underwater (Boyle, McMaster et al. 1995; Balchen 1996; Lin and Kuo 1999; Hirabayashi, Akizono et al. 2006), nuclear reactors (DeJong, Faulring et al. 2006; Basanez, Surrez et al. 2009), underground mining (Duff, Caris et al. 2009), and where the operator has to be isolated from the machine (Hellström, Lärkeryd et al. 2008; Ringdahl 2011; Komatsu 2012).

In summary, some possible benefits of teleoperation of forestry machines based on other field machines are:


As outlined previously teleoperation has many significant potential benefits. The main problems that must be addressed in the development of teleoperation are:

- Determining the sensors required on the target machine.
- Defining the user interface requirements and creating a suitable user interface.
- Ensuring the target machine remains safe at all times.
- Ensuring the operator has sufficient situational awareness.

Section 2 is a summary of the forestry industry in New Zealand. Section 3 is a survey of existing machinery in mining and forestry. Section 4 goes into the aspects of the design of Teleoperation Test and Development Systems. Section 5 covers some test and experimental systems that are useful for developing teleoperation.

### 2. FORESTRY IN NEW ZEALAND

The economy of New Zealand is highly dependent on primary industries such as agriculture, fishing and forestry. In the year ending June 2011 primary