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A Novel Cost Estimation Approach for Wood Harvesting Operations Using Symbolic Planning

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Abstract

While forestry is an important economic factor, the methods commonly used to estimate potential financial gains from undertaking a harvesting operation are usually based on heuristics and experience. Those methods use an abstract view on the harvesting project at hand, focusing on a few general statistical parameters. To improve the accuracy of felling cost estimates, we propose a novel, single-tree-based cost estimation approach, which utilizes knowledge about the harvesting operation at hand to allow for a more specific and accurate estimate of felling costs. The approach utilizes well-known symbolic planning algorithms which are interfaced via the Planning Domain Definition Language (PDDL) and compile work orders. The work orders can then be used to estimate the total working time and thus the estimated cost for an individual harvesting project, as well as some additional efficiency statistics. Since a large proportion of today's harvesting operations are mechanized instead of motor manual, we focus on the planning of harvester and forwarder workflows. However, the use of these heavy forest machines carries the risk of damaging forest soil when repeatedly driving along skidding roads. Our approach readily allows for assessment of these risks.

Keywords: GIS, Forestry, Symbolic Planning, Environment Protection, Cost Estimation

1 Introduction

The process of cost estimation for wood harvesting operations usually relies on experience, codified into official forest assessment guidelines. These guidelines are published annually, for example by the Forestry or Environment Departments of German federal states such as North Rhine-Westphalia [1] or Brandenburg[2]. The harvesting operation costs derived from these guidelines only rely on the estimated total volume of harvested wood and the age and species of the trees affected by the operation. They do not consider individual parameters of harvest operations, such as the types of machinery involved, or the number and position of skidding roads in the affected stand. Therefore, they can only calculate a rough estimate of the costs resulting from a harvest operation.

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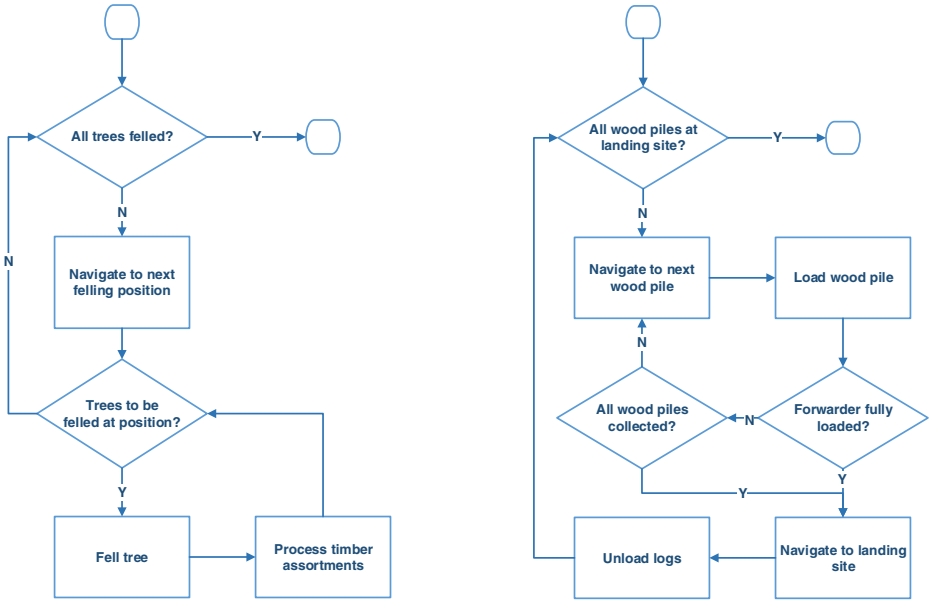

(a) Harvester (b) Forwarder

Figure 1: Simplified workflows of forest machines

A complete work flow simulation, including detailed harvester movements that account for individual path properties, can be used to predict harvesting costs accurately. Planning these movements, however, is a non-trivial task, since available road nets can be quite complex and thus allow for a plethora of possible transition combinations.

One approach to improve the accuracy of cost estimations is the simulation of single harvest operations. Bruchner[3] and Hemm[4, 5] followed this approach, relying on the software AutoMod^{TM} and highly specialized and fine-tuned simulation models to conduct their simulations.

In this paper, we present a flexible and novel approach to accurately estimate the costs of harvest operations, based on knowledge of the parameters of a concrete harvest operation, utilizing symbolic planners.

2 Machinized Wood Harvesting

The general process of fully mechanized harvesting operations (see fig. 2) consists of the work of harvesters and forwarders, with the forwarder working after the harvesters finished their task [6, 7]. The harvester's task is to fell and process a set of marked trees, to process them according to a given, pre-calculated assortment and placing the resulting sorts on wood piles at the side of the skidding road. The forwarder's task is the delivery of those wood piles toward a central landing site where the wood is stored. A model of the workflows of harvesters and forwarders was presented by Asikainen [8].

In order to develop our Symbolic Planning Approach, we adapted and simplified Asikainen's