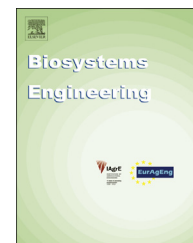




ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/issn/15375110

Research Paper

Sensitivity analysis of a stochastic discrete event simulation model of harvest operations in a static rose cultivation system

Albertus van 't Ooster^{a,b,*}, Jan Bontsema^a, Eldert J. van Henten^{a,b},
Silke Hemming^a

^a Wageningen UR Greenhouse Horticulture, P.O. Box 644, 6700 AP Wageningen, The Netherlands

^b Wageningen University, Farm Technology Group, P.O. Box 317, 6700 AH Wageningen, The Netherlands

ARTICLE INFO

Article history:

Received 27 February 2013

Received in revised form

13 June 2013

Accepted 12 October 2013

Published online 2 November 2013

Greenhouse crop system design for maximum efficiency and quality of labour is an optimisation problem that benefits from model-based design evaluation. This study focussed on the harvest process of roses in a static system as a step in this direction. The objective was to identify parameters with strong influence on labour performance as well as the effect of uncertainty in input parameters on key performance indicators. Differential sensitivity was analysed and results were tested for model linearity and superposability and verified using the robust Monte Carlo analysis method since in the literature, performance and applicability of differential sensitivity analysis has been questioned for models with internal stochastic behaviour. Greenhouse section length and width, single rose cut time, and yield influence labour performance most, but greenhouse section dimensions and yield also affect the number of harvested stems directly. Throughput, i.e. harvested stems per second, being the preferred metric for labour performance, is most affected by single rose cut time, yield, number of harvest cycles per day, greenhouse length and operator transport velocity. The model is insensitive for σ of lognormal distributed stochastic variables describing the duration of low frequent operations in the harvest process, like loading and unloading rose nets. In uncertainty analysis, the coefficient of variation for the most important outputs, labour time and throughput, is around 5%. Total sensitivity as determined using differential sensitivity analysis and Monte Carlo analysis essentially agreed. The combination of both methods gives full insight into both individual and total sensitivity of key performance indicators.

© 2013 IAGrE. Published by Elsevier Ltd. All rights reserved.

1. Introduction

Labour is a dominant cost factor in Dutch cut-rose production. Growers feel an economic need to decrease labour cost and

control labour demand better. Crop production system design and labour management are the key processes for improving labour efficiency. These processes are commonly driven by system evolution and experience. Quantitative models for

* Corresponding author. Wageningen University, Farm Technology Group, P.O. Box 317, 6700 AH Wageningen, The Netherlands. Tel.: +31 317 482143.

E-mail address: Bert.vantOoster@wur.nl (A. van 't Ooster).

1537-5110/\$ – see front matter © 2013 IAGrE. Published by Elsevier Ltd. All rights reserved.

<http://dx.doi.org/10.1016/j.biosystemseng.2013.10.009>

Nomenclature			
C_o	Individual harvest rate of an operator (stems h^{-1})	$p,(\nu)$	Probability density function of the stochastic variable ν
CT_n	Cycle time of node n (s)	σ	Standard deviation of the variable's natural logarithm for $LN(\mu, \sigma^2)$ or the variable itself for $N(\mu, \sigma^2)$
CT_{sn}	Cycle time of subnode sn (s)	SD	Standard deviation (data set)
CV	Coefficient of variation	$S_{i,j}$	Normalised sensitivity coefficient of output y_i for (input) parameter p_j (–)
d_{hc}	Decision parameter, allowed number of harvest cycles ($d_{hc} \in [1,2]$)	t_o, t_f	Start and end time of simulation (s)
D_o	Overlap distance between a move action and a basic rose cut action (m)	T_{bb}	Stochastic variable service time to bind a rose net to a bundle (s)
D_s	Stochastic variable distance between ripe stems (m)	T_{cr}	Stochastic variable service time to cut a single rose (s)
$D_T(n,k)$	Cumulative travel distance operator since t_o within task k in node n (m)	$TH(n,k)$	Throughput of product, average output of task k in node n per unit time (s^{-1}), $k = 1$ is harvest, $TH(n,1)$ is output of harvested stems s^{-1} of CT_n
$\Delta y_i, \Delta y_{i,j}$	Individual absolute sensitivity of output y_i for perturbation in parameter p_j	T_{p1n}, T_{p2n}	Stochastic variable service time to place one, two empty rose nets in the trolley (s)
$\Delta y_{i,tot}$	Total absolute sensitivity of model output y_i for perturbation of a parameter vector P	T_{stb}	Stochastic variable service time to place a single rose in the trolley buffer (s)
$E(\nu)$	Expectation of stochastic variable ν	$T_T(n,k)$	Total labour time on task k in node n (s)
hc	Daily harvest cycle index $hc \in [1, 2](-)$	T_{t1n}, T_{t2n}	Stochastic variable service time to log one, two empty rose nets in the labour registration system (s)
L_{Gh}	Greenhouse length in ridge direction (m)	$T_{Tc}(n,k)$	Total cut time within harvest task in node n (s)
$LT(n,k)$	Lead time on job element k in node n , a management constant indicating target process time	$T_{To}(n,k)$	Total overlap time between actions within task k in node n (s)
μ	Mean of the variable's natural logarithm for pdf-type $LN(\mu, \sigma^2)$ or the variable itself for pdf-type $N(\mu, \sigma^2)$	$T_{Tt}(n,k)$	Total transport time within task k in node n (s)
N	Number of Monte Carlo simulations	$T_{Tw}(n,k)$	Total wait time within task k in node n (s)
n_p	Number of parameters in analysis (–)	$u_o(o)$	Utilisation of operator o
$N_{md}(n)$	Number of rose nets delivered in node n (–)	v_o	Operator velocity at task execution ($m s^{-1}$)
n_{sp}	Number of spans per node $n_{sp} \in [1, 2, 3, 4] (-)$	ξ	Gaussian random variable with $\mu = 0$ and $\sigma = 1$
n_y	Number of outputs in y (–)	y	Vector holding key performance indicators of the model
P	Model parameter vector $P = (P_g P_c P_o P_m)$	y_i	Individual performance indicator, $y_i \in y$
P'	Parameter vector used in DSA test, $P' \in P$	Y_n	Measured yield of the day in node n (stems m^{-2})
P''	Parameter vector used in uncertainty analysis, $P'' \in P$	$Y_n cf$	Gain factor representing a correction in measured yield Y_n (–)
p_j	Individual model (input) parameter subjected to sensitivity analysis		

evaluation of new crop production system designs and new labour management strategies are not available. For this reason, the Greenhouse Work Simulation model (GWorkS) was developed. In Van 't Ooster, Bontsema, van Henten, and Hemming (2012, in press), this model was presented and validated for harvest in two crop production systems for cut rose, a mobile and a static rose production system. GWorkS is a stochastic discrete event model of crop operations in greenhouses. Its purpose is to support designers and growers in improving crop cultivation systems with respect to labour efficiency and quality of labour.

For model-based design and evaluation of systems, it is required to evaluate 1) risks of model or system failure resulting from uncertainty, and 2) sensitivity of key performance indicators for individual parameters. Sensitivity analysis is the suitable technique for both (Macdonald & Strachan, 2001). The aims of this study were to identify 1) input parameters that must be chosen with care so as not to compromise the accuracy of the model prediction, as well as

parameters for which accurate specification is less necessary, 2) features of the growing system to which labour demand is very sensitive and which could guide the designer and producer of a growing system to an improved system, and 3) impact of model limitations and sources of uncertainty on the model's ability to discriminate between alternative work scenarios.

Delivering the aims of this study requires determination of individual sensitivity and uncertainty ranges of model output. Individual sensitivity describes effects of individual parameters on model output. Differential sensitivity analysis (DSA) is widely used to produce individual sensitivity (Lomas & Eppel, 1992). In this study, DSA is a one-at-a-time method varying just one parameter for each simulation while all other parameters remain fixed at their nominal values (Hamby, 1995). The change in a model output is a direct measure of the effect of the change in the single input parameter. However, in a stochastic model, this direct measure may be disturbed by random internal processes. For linear and superposable

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات