P R I N T S I M; TRAINING SIMULATOR FOR OFFSET PRINTING

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Abstract

The simulation technique is a useful alternative to practical training. The newest computer technology has made it possible to develop training simulators for smaller processes, too.

VTT/GRA* has launched a project to develop a training simulator with the capability to imitate offset printing processes in connection with a modern control system. Printers, graphic arts students and scientists may familiarize themselves with process behaviour and its control without being dependent on a large printing machine and the materials involved in offset printing.

The system was taken into use in March 1986 to train printers. The first prototype is capable of simulating the behaviour of heatset and newspaper presses with their control systems. The system will also be connected with our TAPA web offset press.

This paper gives a general description of the PRINTSIM system, its mathematical models, hardware and software structures, and principles of utilization.

1. INTRODUCTION

Until now the simulation technique, used successfully for various purposes, has been connected mostly with large computers. Today's computer technology has made it reasonable to construct simulators also for smaller processes, whose control requires a good theoretical background or lots of practical knowhow.

VTT/GRA has launched a project to develop a training and research simulator with the capability to imitate offset printing processes in connection with a modern control system. The system should simulate the process

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* VTT/GRA– The Graphic Arts Laboratory of the Technical Research Centre of Finland

dynamics and react on the commands activated in the most important situations of the run. The system is called PRINTSIM.

2. MODELLING PROBLEM

Offset printing is the most time-dependent printing process and that makes it difficult, for example, to stabilize the print quality.

According to the goals of the project we had to model both the basic dynamics of the webs, inks and water, and a group of trend-like mechanisms with their effects on the product quality.

As a simulation problem PRINTSIM includes plenty of dynamic calculations, a system of static model equations and generation of routines representing the various situations in the actual production. Figure 1 gives an illustration of the mechanisms modelled in this system.

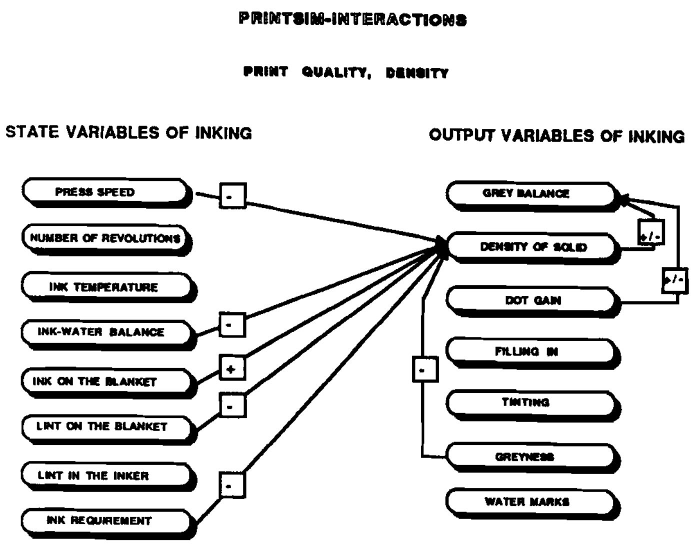

Figure 1. An example of variable's interaction in the process model. State variable: inking; output variable: print density.

In this application the goal was to construct an active and realistic whole. Therefore both the models and the numerical routines have been formed "as plain as possible - but not too plain".

2.1 Web dynamics

The web advances from one nip to another.It receives water and ink in each printing unit and changes its elastic parameters. The machine speed changes and tension levels change in time. Tension disturbances may be caused by e.g. an elliptical paper roll.

We can, for example, generate an elliptical paper roll, which activates tension disturbances according to the roll size. The disturbances go through several nips, while the web receives water and ink. The tension errors can be seen as register errors colour by colour.

The web model equations include following output variables:

Momentary roll diameter
Local momentary tension
Momentary tension disturbance of a unit
Local register error in the machine direction
Local register error in the cross direction

The outputs are computed according to the values of:

Amplitude of the tension disturbance
Initial roll diameter
Print cylinder diameter
Paper thickness
Simulation revolutions
Momentary machine speed
Distance between succeeding printing units
Local momentary elastic module

2.2 Ink and water dynamics

The inker consists of a system of rolls to feed ink and water. The water is emulsified, split and evaporated. The printed image is formed by rasterized ink layers combined with water.

Since we have had to minimize the computing time to reach the real time simulation, we have modelled the ink and water dynamics by transfer functions. These functions include one time constant and one dead time. The time constants of ink are calculated zonally according to the theoretical ink need. The direction of the changes is also taken into account by the time constants. The program estimates water emulsification, splitting and evaporation. The estimation in the models is carried out by means of parameters given at the start of the simulation.

2.3 Density formation

The main numerical indicator for the print quality is the density level of each colour increment in question. PRINTSIM calculates the density levels, and in the case of a heatset line simulation, the printed output is illustrated by professional graphic displays on the PC.

The image density levels are computed on the basis of the momentary ink and water feed levels, layout of the print and parameters of the density formation. The computation includes the effects of variables like dot gain, paper surface roughness, ink emulsification rate, etc.

The print quality depends on the registers, and amounts of ink and water.

An RGB-image is to be generated on the basis of the density levels of each colour. The screens include fulltone vision on the print look out, local density profiles of each colour, machine and cross directional register values and indications of water marking or toning.

Web breaks, etc. generate messages and advice to the operator.

2.4 Generation of RGB-values for the PC screen

Special computation is needed to transform the computed densities of the four process inks to the values of the three basic colours of an RGB-video display unit. This RGB display serves as a printed image simulator.

2.5 Trend-like changes

There are certain trend-like changes in the state variables of the process depending on the rub off the plates, changes in the rheology and in the surface chemical characteristics of water and ink, etc. These changes can be taken into account by the trend equations, into which practical knowhow of the process is installed.

2.6 Special situations

There are several situations during a run (runs up and down, web breaks, print defects, etc), in which practical knowhow of the process is needed besides logic.

To make the run more interesting we have outfitted the program modules with tests to check the roll sizes, web flutter, local tension levels, register errors, relative amounts of water and ink, relative density levels, etc. As soon as the program activates a routine for a special situation, advice and messages are given to the operator (these may be text or graphic illustrations).

The recoverings have been made as realistic as possible. For example, in the case of a web break the machine stops automatically and the operator has to make the right adjustments in the ink and water systems to avoid a rebreak immediately after the restart.

2.7 Actuator simulations

There is a group of actuators (ink screws, ductor speeds, registers, alarm signals, etc.) in the control system without a response.

Actuator effects and responses are imitated by the down level simulations. For example, the actions of ink screws and registers are calculated on this level.

2.8 Sequential and presetting routines

Other PRINTA routines include sequential and presetting activities. For example, the on/off-connections of the inking and dampening units are such routines.

Various presettings, e.g. registers, ink and water feed levels, can be made on the basis of the data in the memory of the system.

3. HARDWARE

Figure 2 illustrates the PRINTSIM hardware consisting of:

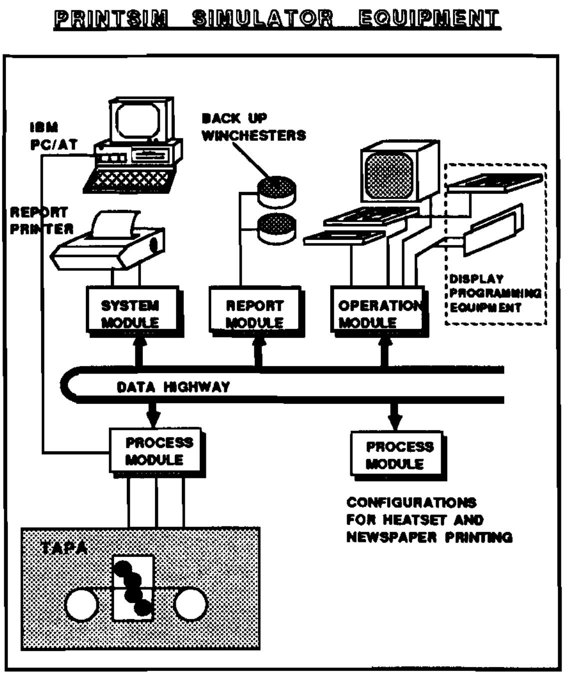

Figure 2. PRINTSIM hardware.

- two process stations
- a reporting station with two winchester stations
- a system station
- an operating station
- a colour video screen with

- an operator keyboard and
- finger pointers
- a keyboard for ink screws
- a report printer and
- a PC connected with one of the process stations
- an ALCOM data highway

For the simulations the PC has a high-resolution professional graphics monitor to display print quality (colours, registers, ink and water amounts, print defects).

4. SOFTWARE

The functional software of the PRINTSIM is sketched out in Figure 3.

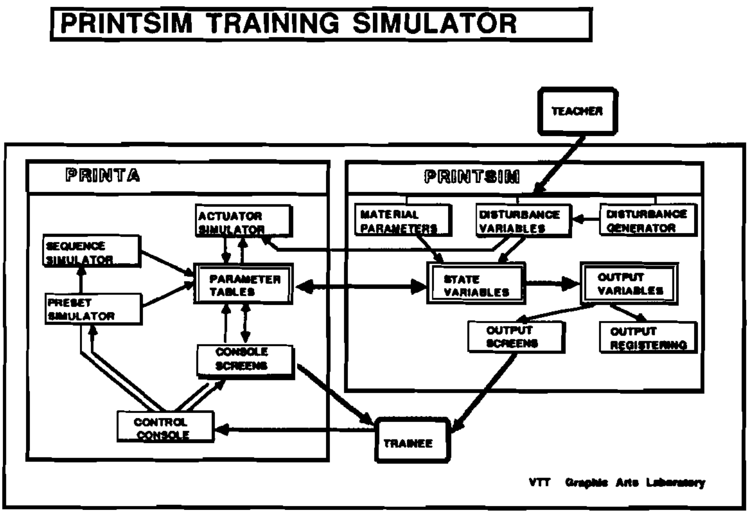

Figure 3. PRINTSIM software.

The programs in the control system PRINTA provided by Altim Control Ltd are stored during the run in the RAMs of the various stations. Standard remote control routines are connected with actuator simulator routines constructed by the VTT/GRA. Other PRINTA routines include sequential and presetting activities.

PRINTSIM programs are installed in the PC, which communicates with PRINTA by means of the communication routine to allocate the parameters that carry the information on the process state. By modifying the communication routine the simulator can be connected with other vendors' control systems.

The teacher activates the PRINTSIM by an interactive routine and gives the essential input parameters for the run. These parameters include material parameters and arguments for the disturbance generation.

The process state is calculated by the dynamic models of the process followed by the static model routine.

The output state of the process is illustrated by professional graphic displays on the PC. The screens include fulltone vision on the print lookout, local density profiles of each colour, machine and cross-directional register values and indications of water marking and toning. Web breaks, etc. generate messages and advice to the operator.

Disturbance generation routines cause disturbances during the run, which must be compensated by the operator.

The different situations during the run are reported by the system printer. A set of characteristic numbers are included in the report to indicate the success of the trainee.

5. ACTIVITIES DURING A SIMULATION RUN

During a simulation run the trainee sits at the control console and follows the process and product states on the video displays. Based on the observations he gives commands to the system by the console and by finger pointers. The effects of these commands are calculated by the process model equations and the results are indicated as changes in the state of the product. Time delays and reactions to various disturbances are modelled after real production machines.

6. FUTURE DEVELOPMENTS

This kind of simulator systems are rather interesting, because they test application knowhow, simulation techniques and hardware. Although the capacity and speed of the computing system set strict limits, the system should function in real time, be illustrative and easy to learn and handle.

As a simulation application PRINTSIM includes, besides exact mathematical algorithms, plenty of ideas carried out in team work case by case.

We have also made plans for the next phase, PROOFSIM. We intend to get more precise information on the print quality of the process. Multicolour image formation and printout simulations will be our next target. Also visual image and graphics based methods for process control engineering are in our list of interests.