Efficient merging of streams of sheets in industrial printers

Cost-effective, high-quality, on-demand printing of books and customized transactions requires large industrial printers to maintain a high productivity at low running cost. Industrial printers print hundreds of images per minute. They are essentially small production lines that use a single print station to print duplex sheets. To improve productivity of such industrial printers, we have created tools that can already be used in an early developmental phase of new machines.

Productivity, cost and print quality of an industrial printer depends on the interaction of all kinds of physical and chemical processes. After a sheet is printed with water-based ink, it is heated to evaporate the water. The sheet is then cooled down, and flipped upside down in the duplex loop. Subsequently, the back-side is printed and after heating and cooling again, it is stacked at the output.

Many processing constraints need to be taken into account, and each sheet is unique. The sheets cannot stop moving as this will result in wrinkling or even a paper jam. They undergo these processes, as orchestrated by a high-level process controller. The productivity depends on the constraints imposed by the physical execution of the processes for a single sheet, as well as the effectiveness of interleaving unprinted sheets with once-printed sheets. Interleaving sheets can be thought of as the merging of two lanes on the high-way, but where the required safe distance between cars depends on who is in front of them. We have contributed a controller that decides well within a second in which order the cars should merge. If the controller makes poor merging decisions, or takes too long to compute a decision, the productivity drops or the paper jams.

Many architects and engineers need to collaborate for quite a long time to prototype and realize new printers. The key performance indicators of industrial printers are performance, quality, and cost. The print quality is a result of the interaction of the transportation mechanism and the ink jetting station. If a sheet arrives that is for example thicker than the previous sheet, the ink jetting station needs to adjust the height at which the droplets are jetted. Such adjustments take reconfiguration time. The productivity depends on the execution of a single sheet and the reconfiguration times between different types of sheets. During the design phase it is useful to provide feedback from total aspects such as productivity to the multi-disciplinary subsystems. Therefore we have created a set of tools that perform simulations of the execution of the merging strategy, and compute the sensitivity to changes in the execution of sheets. These tools also take into account that changes in the physical transport or reconfiguration times may lead to a different merging strategy.

These results are useful to discuss the impact of changes in early design decisions of new industrial printers. It is not necessary to wait for the completed prototype to assess the productivity. Architects, designers and engineers can then make informed decisions on whether it makes sense to optimize the cost of a process.