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MODELING AND SIMULATION OF FRESH MEAL PRODUCTION

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1 INTRODUCTION

The rapid development of e-commerce in recent years, particularly through the use of mobile devices, has led to the development of new enterprises in the field of fresh produce e-commerce (He et al. 2019). More and more companies now sell fresh meals to consumers through e-commerce platforms, and online sales of fresh produce have grown considerably as a result. Gousto offers a meal subscription service where customers choose their meals for a week, and a box is subsequently delivered with all the ingredients (fruits, vegetables, meat, cereals, herbs, etc.) needed to prepare those meals, along with step by step instructions on how to cook the recipes.

To fuel its continued growth, Gousto has been improving the efficiency of its existing factories, building new factories with higher automation, capacity, and flexibility, and is continuously increasing the number of recipes offered to customers. This has lead to a significant additional complexity of the production processes, with e.g. the question of the right qualifications (i.e. ingredients assigned) of the workstations in the factory, as for example studied in (Perraudat et al. 2022) for semiconductor manufacturing. To support the improvement and the design of factories, the design of a simulation model has been initialized on a first limited scope, which is currently being extended. The first results of the simulation show the impact of key parameters on various performance indicators.

2 INITIAL SIMULATION MODEL

Figure 1 shows a simplified view of the production flow on four workstations. A factory may include more that 150 workstations. When the processing of a box is started, the information on all its required ingredients is known. Each box follows a route to be processed in a given order on some of the workstations in which the assigned operators add the required ingredients. The route depends on the recipes ordered by the customer. Moreover, depending on the inventory level of a required ingredient in a workstation, a box may have to return later to the workstation, or visit another workstation which currently has the ingredient available.

An intermediate model with 35 workstations has been developed as a discrete event simulation model using agents for the boxes and implemented using Anylogic 8.5. Industrial data have been used to develop the simulation, in particular for factory layout, conveyor speeds, routes and the processing speeds of the workstations.

The main objective of the first simulation model was to prove the ability of a simulation approach to quantify the effects of line optimisations such as workstation qualifications. Various Key Performance Indicators (KPIs) are used to analyze the impact of such changes and characterize the efficiency of the line. The KPIs include the line throughput (number of boxes produced per hour), the average time to complete each box, and the station utilization rates.

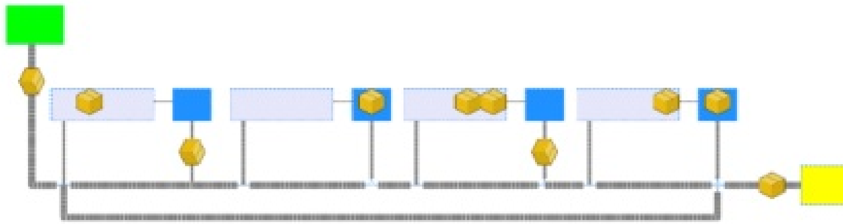

Figure 1: Simplified view of the production flow.

3 FIRST SIMULATION RESULTS

Our first simulation experiment comprised two scenarios. Both scenarios use the same model, and start the same 1,000 orders. As soon as space and count constraints allows, new orders start to be processed. The two scenarios differ by the box routes: Scenario 2 has 21% fewer stops per box (2.8 vs 3.6 average number of box stops), and (in theory) a more balanced allocation of boxes to stations than scenario 1. Scenario 2 corresponds to the case where the algorithms developed by Gousto optimise both the ingredient allocation to workstations and the order routing, whereas scenario 1 corresponds to the (non-optimised) baseline.

In terms of KPIs, scenario 1 shows a throughput of 790 boxes per hour, an average box cycle time of 16 minutes, and an average station utilisation of 80%. In scenario 2 (where on average boxes have 21 percent fewer stops), the throughput increases to 1,208 boxes per hour, the average cycle time decreases to 11 minutes, and the average station utilisation increases to 91%.

Though the dominance of scenario 2 over scenario 1 was expected, the magnitude (53% increase in throughput) really characterises the non-linear effect of optimisation and surprised most non-experts at Gousto. Indeed, even though the improvement in terms of box stops was only 21%, this improvement helped to create far less congestion in the line, and also helped to balance the line (for a better overall stations utilisation).

4 CONCLUSIONS AND PERSPECTIVES

An initial simulation model has been developed for the production of recipe boxes. The first numerical results showed the interest of the model to point out critical parameters of the production line, and how modeling and simulation can be used in the future at Gousto to evaluate the impact of optimisation algorithms.

In the conference, extensions of the first simulation results will be presented and discussed. In particular, various scenarios are being tested. The increased automation of new Gousto factories, in particular automated transportation and storage, requires the development of simulation models to validate the proposed production, transportation and storage policies, as for example in semiconductor manufacturing (see (Aresi et al. 2019)).

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