Automatic Design of Vibratory Feeders using Dynamic Simulation

Maintaining an economically feasible manufacturing industry in high wage countries is a challenge. This is especially the case for small and medium sized enterprises, which often have to deal with small batch productions with high product variance, to which classic automation is ill-suited. To handle this type of production, flexible manufacturing equipment, which can easily be adapted to new production tasks, is required. A recurring problem for flexible automation, which is especially evident in the branch of the industry dealing with assembly, is part feeding. The term Part feeding covers the task of getting the parts (objects), used in the assembly, into the hand of the robot performing the assembly. This task is typically handled by a specific family of automation equipment, which is referred to as Part feeders. There exist part feeders using modern sensor technology to obtain flexibility, but these are typically expensive investments and are not guaranteed to be able to handle every feeding task. The Vibratory Bowl Feeder is a widely used part feeder in industry. The vibratory bowl feeder uses a set of mechanisms, called Traps, to ensure that parts leave the device in a specific orientation and can be designed to feed almost any part type. However, the vibratory bowl feeder is typically so specialized that it can rarely feed more than one part type without needing to be redesigned. Vibratory bowl feeders are made from inexpensive components, but the price of this feeder type can vary heavily. This is because designing them to work properly is difficult and that this design task is currently handled by experts relying on past experience and trial-and-error approaches. If the design task is be handled more efficiently, the related cost can be reduced. This will potentially lead to vibratory bowl feeders becoming so cheap, that these can be purchased for every feeding task with little economic impact for a company.

The focus of this thesis is therefore on designing vibratory bowl feeders with a more structured approach. To this end, a method for design has been developed and programmed as a software application. The software uses physics simulation of objects in motion, similar to what can be found in many modern 3D computer games. The simulation is used test the performance of feeder designs without the need to actually built it in the real world. This saves time and expenses.
This PhD-project provides an investigation of the how well the simulation mimics the real vibratory bowl feeder. The focus is then on how to best use the simulation in for design. First, an approach is explored in which a person designing the bowl uses the simulation to help make the design task easier. Then, approaches to fully automatic design are investigated that involves no human designer. First, a method is investigated for automatically adjusting the individual traps to work best on the specific part to be fed. Secondly, a method is presented, which automatically figures out which traps is useful for correctly orienting the parts. This also includes determining the order which the chosen traps should be in, to work as intended. All these methods are incorporated in the developed software, which is presented in the thesis.

The sum of these research contributions advances feeder design towards making the technology more accessible for the industry at a lower cost.