

Automated Storage & Retrieval Systems

Introduction

The goal of the Automated Spice Mixer is to give the user a greater control over spices and other dry powders in the kitchen. One key aspect of the design of the machine is its ability to automate the process of storing and retrieving ingredients. Some of the variables to account for are: speed of retrieval, number of available containers and the accuracy of the machine (i.e. does it always retrieve the right container). Automated Storage and Retrieval Systems (AS/RS) are used at all scales, from very large systems for automated factories [1], to smaller scales in Biology and Chemistry laboratories [2,3]. This technical review summarizes some commercially available AS/RS systems available for kitchen scale, displays the main design choices that are relevant to a Spice Retrieval system, and provides a potential choices that would suit the application.

Commercially Available AS/RS systems for kitchen applications

AS/RS have not yet been implemented for a kitchen setting, they do however exist in the context of storing and retrieving chemicals or biological library storage. "The Scientist", a scientific magazine exhibits a comparison of three commercially available systems [2]. There are several systems on the market, which differentiate themselves on the following aspects: extent of automation, number of containers and pricing.

1. Extent of automation: Some of the AS/RS systems can only perform simple automated tasks, such as the Freedom EVO [3]: storage and retrieval, but any other task, such as filling the pipettes or feeding the biological cells must be done manually. On the other hand, other systems, such as the Compact Select [4], more complicated systems can have a programmable robotic arm that can handle more complex tasks. Nevertheless, the Freedom EVO machine is cheaper than the Compact Select system, costing only \$50.000 for the smallest available size while the cheapest Compact Select costs \$600.000.
2. Number of containers and size of system: Because the size of the machine must be minimized, in order to save space in the Laboratory where the machine is installed, the number of containers that the system can store at once. For instance, the smallest size offered by Select is of 90 Flasks, which will take a surface area of 2.75m x 1.1m, whereas the smallest Freedom EVO design handles 100 flasks for a surface area of 1.08m x 0.87m.

In conclusion, some applications of small-scale AS/RS systems have already been created, but they are more technology intensive, and are much more expensive than our target price for a Spice Storage unit. However, some of the AS/RS design decisions can be used in a Spice Mixer implementation too, as they operate on the same scale and deal with similar constraints such as space efficiency and speed and accuracy of retrieval.

Technology of an AS/RS system

In order to build an AS/RS systems, two things must be picked: the storage layout (or “warehouse”) and the software implementation for scheduling. Each part of the AS/RS system has multiple implementations that are introduced.

1. The storage:

Several layouts have been proposed for the organization of the different compartments of the AS/RS systems. The most typical layouts are the Vertical Lift Module and the Horizontal Carousels. In the Vertical Lift module, the storage is organized in multiple vertical shafts, similar to a library, where the items are placed on the shelves of each shaft. The advantages of Vertical Lift Modules is retrieval is fast and the packing density is high: almost no space is wasted. The disadvantages of VLM are that storing and retrieving involves more operations, and can be more complicated to implement. In Horizontal Carousels (HC), the shelves in the storage are not at a fixed position in space can be rotated. There are points of access where a single shelf can be accessed once it reaches a position (door). The advantage of HC is that they can be of any scale and involve simpler robotics than a VLM. On the other hand, the size of each module in an HC is typically fixed, and retrieval time for HC can be slightly longer than VLM.

2. Software implementation for packing and scheduling

An AS/RS system can receive multiple instructions at once: in the case of a spice mixer, when several spices are requested at once. Therefore in order to maximize efficiency of the machine, several methods for path minimization have been proposed [5,6]. One method is to partition the machine in different “zones” that deal with the different types of stored elements [5]. In the case of the Spice Mixer: spices would be stored in one zone, while flour, sugar would be in a different zone. Another method involves arranging products by frequency of use dynamically [6].

Implementation of an AS/RS system for a Spice Retrieval application

Implementing the storage as a Horizontal Carousel instead of a Vertical Lift Module might limit the number containers available, but it will also simplify the process of grabbing containers. Also, rotating the containers in the Spice Mixer application is not a limitation, and the spices aren’t typically heavy, rotating the containers is therefore viable.

For the packing and scheduling method, using a system of “zones” (also named classes) is desirable as the fetching requests will typically involve several items of the same type (i.e. the user needs 2 spices, or flour and sugar), which will be faster to fetch with a zone layout [7]. Overall, the goal of the AS/RS system in the Spice Mixer application is to remain simple, compact and efficient. These implementation choices should help achieve the goals that are set for the Automated Spice Mixer.

References

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