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Product identification methods using drones

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Abstract

In this paper, we present a product identification method based on a mathematical model and solution for inventory management with drones developed by us to perform inventory management tasks in a multi-user mixed warehouse where neither satellite positioning nor other IoT solutions can be used.

The use of drones in product identification. Warehousing plays an important role in the process of supply chains and networks. Modern, fast warehousing requires the secure, rapid identification of products stored in warehouses. In modern warehousing, the identification of products needs to be done automatically, as manual inventory work is inefficient and more prone to errors. In our previous studies, we investigated modern inventory methods within high-bay warehouses. For inventory, we used autonomous drones capable of taking photographs along a predefined, optimal route that ensured the safe progress of each drone. The mathematical model and method for determining the optimal routes were also described in the previous paper [4]. However, the method needs to be coupled with an efficient product identification solution, since the drones take photographs as they move between each compartment. The photographs are not processed by the drone but sent to a central pre-processing system. To take high-quality pictures, the drones move down the middle of the aisle and stop in the middle of each compartment for good visibility. During the inspection of a particular compartment, once the drone has found its photo position, it takes a photo of the compartment and sends it to the pre-processing system (in our study, this is a high-capacity tablet) where the pre-processing application is running. The first test during preprocessing checks the quality of the image (in terms of brightness, sharpness, distractions). The drone does not change its position until the preprocessing application instructs it to do so. If the image is not good, the pre-processing application will have the drone take another image. If the image is good, the drone will continue its journey.

Product identification using QR codes. To automate inventory management in a large warehouse, a drone-mounted camera scans a pre-displayed QR code. The drone runs along the navigated route and manages the warehouse inventory by scanning the barcode or QR code attached to the product. Unlike warehouses, however, which have well-defined grids or shelves, the storage location of products in a yard is flexible rather than fixed. Thus, to manage inventory efficiently in a warehouse yard, the location of QR codes attached to products must be estimated. Some literature has proposed a position estimation method based on the segmentation model of QR codes for drones and products. The segmentation model is used to detect the region of a QR code with perspective distortion caused by the angular difference between the camera and the QR code. Subsequently, shape correction and decoding of the detected QR code region were performed to determine whether it is a ground QR code and the drone's position was estimated. Finally, the 3D coordinates of the QR code attached to the product, rather than the ground QR code, were calculated from images taken by the drones from two different viewpoints. Consequently, the 3D position coordinates of the drones and the QR codes attached to the products were estimated using the ground QR codes, and thus an efficient inventory management was achieved in the warehouse. In our case, fortunately, we work with a predefined, complex warehouse layout. The warehouse structure can be learned by a prior structure recognition algorithm using the preceding. We will develop this in the next phase of our research.

A key aspect in our research is the use of QR code. This is a two-dimensional matrix barcode using the ISO/IEC 18004:2006 (18004:2015) standard. QR code generation is a simple process, but accurate and fast recognition is a challenge for programmers. Getting information from a QR code in a real-world environment involves three vital steps: localization, image pre-processing and decoding. Localization is the detection of a QR code and its exact coordinates or location on an image. If the image is "flawless", the second step can be omitted. However, experience has shown that drone images are affected by a number of external factors, e.g. in low light conditions the QR code is not exactly in front of the camera, so distortion appears. Image pre-processing is an intermediate step in which the detected QR code image is corrected to reduce blur, distortion, angular perspective, etc., for accurate decoding [1, 3]. Decoding is the final step where the information (data) is retrieved and is based on the QR code standard.

Figure 1. Steps to obtain information from a QR code (source: figure edited by the author).

The processing of product identification. As you move along the aisle, the drone searches for the bins, then takes a photo of the bins and sends it to a pre-processing device (in our study, a high-capacity tablet) running the pre-processing application. During preprocessing, the first scan checks the quality of the image (in terms of brightness, sharpness, distractions). The drone does not change its position until instructed to do so by the preprocessing application. If the image is not good, the pre-processing application will have the drone take another image (up to three times). If the image is good, the drone will continue its journey. When processing the image, it is necessary to check if the photo contains a QR code. If so, its content is read. If successful, the content of the QR code is sent to the central application and its processing status is set to successful. If not, the processing status of the slot is set to failed. If no QR code is found, an empty compartment comment is entered (this of course does not always mean that the compartment is actually empty, but the central application will decide if it is empty or if it is a processing failure). In this case, the drone is always sent on to the next compartment. Further processing is always done in the central application and depends solely on the capabilities of the central application. A description of the processes involved is beyond the scope of this paper. After processing each compartment, the pre-processing application sends to the central application the position and processing status of the compartment and the data contained in the QR code.
According to our proposed model, the preprocessing system knows the exact location of the drone in the warehouse, i.e., the 3D data within the warehouse is determined. This and the QR code sent can tell the inventory management model exactly where the product is located or if the space is empty. The pre-processing application also contains previously defined optimal routes for each drone, which is optimized primarily for the drones' operating time, including the time to recharge if the drones are discharged [2]. The proposed solution method is not only suitable for inventory control but also for solving other problems that fit the model.

References

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