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Implementation of Rfid for Effective Object Tracking

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ABSTRACT: *In recent years automatic identification procedures (Auto ID) have become very popular in many service industries, purchasing and distribution logistics, industry, manufacturing companies and material flow systems. Automatic identification procedures exist to provide information about people, animals, goods and product in transit. The omnipresent barcode labels that triggered a revolution in identification system some considerable time ago are being found to be inadequate in an increasing number of cases. Barcodes may be extremely cheap, but their stumbling block is their low storage capacity and the fact that they cannot be reprogrammed.*

I. INTRODUCTION

In recent years automatic identification procedures (Auto ID) have become very popular in many service industries, purchasing and distribution logistics, industry,manufacturing companies and material flow systems. Automatic identification procedures exist to provide information about people, animals, goods and product in transit.The omnipresent barcode labels that triggered a revolution in identification system some considerable time ago are being found to be inadequate in an increasing number of cases. Barcodes may be extremely cheap, but their stumbling block is their low storage capacity and the fact that they cannot be reprogrammed.The technical optimal solution will be the storage of data in a silicon chip. The most common form of electronic data carrying in use in everyday life is smart card based upon contact field (telephone smart card, bank cards). However, the mechanical contact used in smart card is often impractical. A contactless transfer of data between data carrying device and its reader is far more flexible.

II. LITERATURE REVIEW

2.1. Discovering aggregates

A time-based approach to determining aggregates is proposed. This approach relies onconstraining the flow of each aggregate as it moves past the RFID tag reader. Specifically, there must be a delay both before and after each aggregate is detected by the reader where no tags are detected. In addition, while the aggregate is 'seen', the associated tag read eventsshould not be separated by too much of a delay. Define a string of tag read events occurring at a particular tag reader r as

$s(r)=(e_1,t_1), (e_2,t_2)\ldots\ldots\ldots\ldots(e_n, t_n)$

wheree_k is a tag read event that occurred at time tk. This string is ordered by time such that if $a < b$ then $t_a<t_b$. Assume that the aggregate moves past the reader over a particular interval of time and that there are no other tagged objects within the read range at the same time as the aggregate. In this case, all the events for the aggregate passing by the reader will be contiguous within s(r). To ensure that the aggregate can be detected unambiguously, the events for the aggregate should be separated from other events by some time period K. Formally, the sequence of read events $\{e_a, \ldots, e_b\}$ belong to a single aggregate if and only if $t_a - t_{a-1} > K$, $t_{b+1} - t_b > K$ and also iff $t_{i-1} - ti < K$ for all $a < i < b$.

The choice of the parameter K must be sufficiently large to ensure that a single aggregate is not considered to be two separate objects but, at the same time, sufficiently small so that two aggregates arriving one after the other are not considered as though they were a single object. For example, K should be large enough so that if a tag at the leading edge of the aggregate is seen as soon as the object moves into the field followed by a tag at the trailing edge being seen when the aggregate leaves the field, then the aggregate is still seen as a single object. Specifically, for an aggregate of length la travelling at a fixed velocity n past a read field of length lr (as shown in Figure 6), then we require that

$$K > (l_a + l_r)/v:$$

. In some cases, it may be necessary to constrain the flow of aggregates to ensure that each arrives at the reader a small time after the prior aggregate has moved out of the way. Specifically, let the distance between two aggregates (from trailing edge of the first to leading edge of the next) be d, as shown in Figure 6. Then an additional constraint is K < (d - lr)/v which can be rearranged to give a spacing requirement of

$$d > Kv + l_r$$

Another issue is that of whether it is allowable for the aggregate to stop near the reader. The maindifficulty with this is due to the existence of regions near the reader where a tag can be placed indefinitely without generating a tag read. For the above approach to work, it would be necessary to set K to be at least as large as the maximum time spent stopped.[5]

One reason that it may be necessary to slow down or stop the aggregate as it passes through the read range is to allow all of the tags to be read. If an aggregate involves many sub-components, and at least some components are tagged, then multiple tags will be in range of the tag reader simultaneously. Obviously if all tags attempt to respond simultaneously then their signals will interfere. For this reason, tag readers and tags typically employ some form of anti-collision protocol, such as ALOHA or binary search. ALOHA is one of the simplest mechanisms and relies on each RFID tag only responding intermittently thus reducing the probability of a tagcollision.[2]

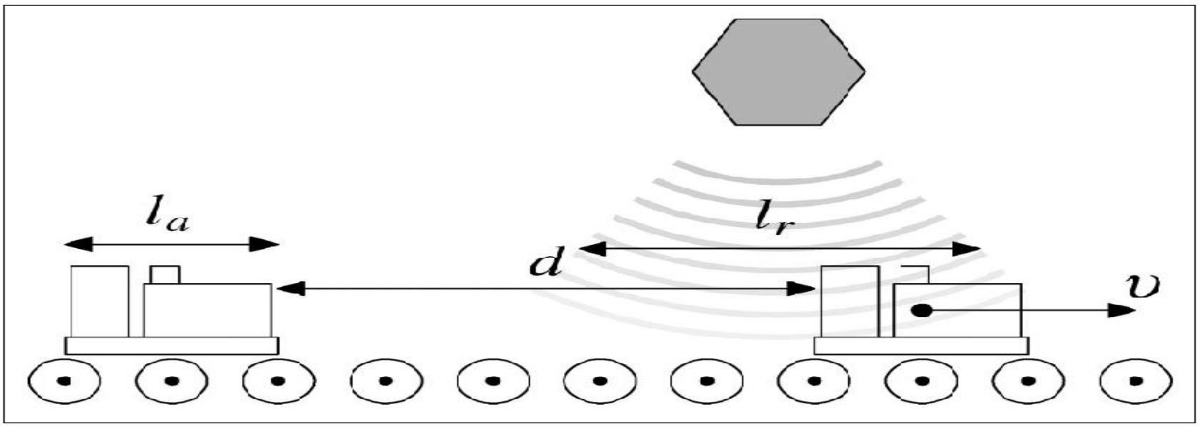


Figure 6.Example of two aggregates moving along a conveyor, past a RFID antenna. The length of the aggregate la, its velocity v, and the size of the antenna's field lr are related to the minimum allowable distance d between aggregates.

However, as the number of tags increases, the length of time needed to be reasonably confident thatall tags have been detected also increases. For a 99.9% confidence level, for HF tags, 0.5 s is required to see two tags, whereas for eight tags, 2.7 s is required. Different anti-collision protocols have different characteristics but all require longer periods to recognize larger numbers of tags.

Given that tag collisions and other environmental factors may result in some tags in the aggregate being missed, tracking the movement of the aggregate, rather than the individual object, allows such missed tag reads to be inferred. This is a key benefit of this approach.Once aggregates have been discovered, prior knowledge about the characteristics of the taggedobjects can help to infer the aggregate's likely structure.

2.2. Inferring containment relationships

When a set of objects form an aggregate, it is usually the case that at least one of the objects acts as a container. For example, a pallet that supports cases can be considered to 'contain' those cases, in the sense that if the pallet moves, then so do all of the associated cases. The converse is not necessarily true. Sometimes a case will be removed from a pallet. The notion of containment is naturally hierarchical, and so cases may contain, say, bottles of wine. When the case is removed from the pallet, the bottles contained within that casewill move too.

In any given application, there are typically only a few levels of the containment hierarchy, and also only a few ways that containment can occur. To infer the likely containment structure, it is usually sufficient to know the likely containment level of each type of object. When several tagged objects exist at the same level, for example two cases are detected but only a single bottle, then it is not possible to infer the location of the bottle. However, it is possible to say that, in the absence of any other information, that it is equally likely for the bottle to be in either case. This probabilistic representation of the position of the bottle may not be useful immediately, but if subsequently one of the cases is removed, and the pallet subsequently passes by a reader, the absence of the bottle at this stage implies that the bottle is more probably in the case that was removed.

2.3. World state representation

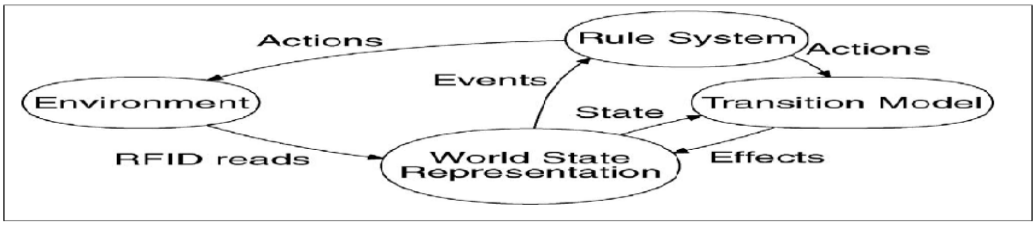
In order to concisely represent the state of a large number of tracked objects, some simplification andapproximation is necessary. RFID reads are only detecting objects at a finite set of known locations L. Allowing objects to act as locations is the mechanism for representing containment. This approach means that when the aggregate moves, only the bottom level container location needs to be updated. The index k is used to represent putting multiple objects into a single container at the same level of containment. The timestamp t keeps the time of the most recent update thus allowing old, out-of-date, RFID data to be discarded. Finally, the likelihood estimate w is used to determine which of several objects is actually at a location based on the relative frequency of receiving RFID reads.

2.4. Transition model

In its essence, tracking involvesdetecting when the state (location) of an object changes. Such change occurs either through explicit control action (such as a robot picking up and moving an object) or implicitly (such as objects falling down a hopper or flowing along a conveyor belt).

A key issue with the development of the transition model was the correct handling of asynchronous updates to the world state from the transition model and RFID sensors. Network and processing delays can mean that the last few tags read for an object that has just been moved away from a reader arrive after the transition model has updated the location of the object. In early versions of the development of this approach, the model indicated that an object apparently ‘jumped’ back to its previous location. This was clearly not the case but the result of processing old RFID data after updating the object state based on an action. To resolve this, RFID read events are timestampedat the source and any events older than updates from the transition model are ignored. The interaction of RFID sensor data, the transition model, the rule system and the world state representation is shown in Figure 7.Generation of control actions is not performed by the transition model, nor by a planning system based around the transition model. Instead, a reactive rule system is used. Following an approach suggested by Nilsson (1994), the rule system is goal-oriented and has a recursive structure. Each rule is a combination of a predicate and an action.

Figure 7.The flow of information within the overall system.



For example, a sub-goal might be to pack a box with a gel, a foam and a razor. This then breaks down into the rules to move the box to the robot and then to move the individual items into the box. The rules are ordered so that rules about situations close to the goal are presented first, while situations further from the goal are presented later.

Evaluation

To evaluate the approach to object tracking described in the previous section, it was applied to the Cambridge laboratory manufacturing system mentioned previously. This system packs GilletteTM gift boxes. As with previous development phases, it packs to order rather than to stock. It extends earlier work by both routing parts and boxes to the appropriate cell and flexibly handling the packing operation of a single box across several cells.Theorder can be changed at any stage during production, causing the gift box to be repacked in an efficient manner. A schematic diagram of part of the manufacturing system is shown in Figure 8.

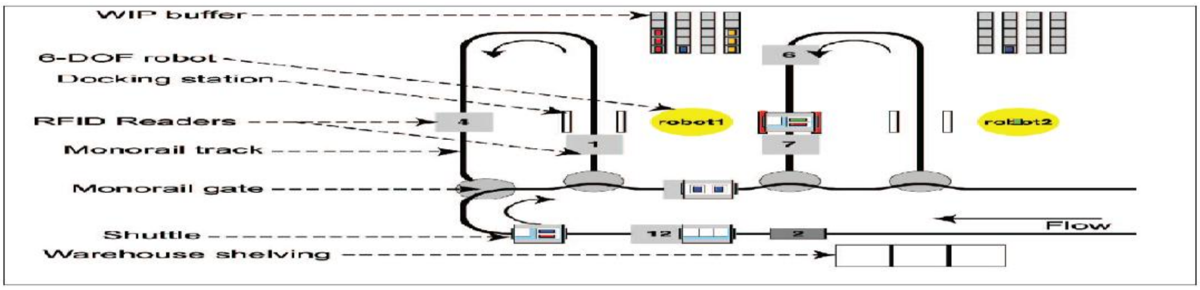


Figure 8.Diagram of the gift-box packing system. Solid arrows show the direction of flow of goods on a monorail track.(Phase 3)

To allow the location of parts to be identified, RFID tags are attached to the individual items (gel, razors, foam, or deodorant), the boxes, the trays carrying the boxes and the shuttles. RFID readers are positioned at the base of the work-in-process (WIP) stacks (see Figure 10) and along the monorail track just prior to the gates and docking stations. Although the original design called for readers prior to every decision point, some readers were able to be disabled, although some slight changes were required to the transition model to cope with this. The experimental work performed in this paper made use of a simple form of HF tag that uses an anticollision protocol of transmitting every 100 ms + 50%, but with each tag factory set to use a slightly different period. The readers used can perform some simple filtering (such as filtering recently seen tag messages), however this was turned off.[11]

Figure 9: Mixed products packed by Cambridge packing cell

The aim of the experimental evaluation was to assess how many incorrect RFID-derived inferences could be removed by superimposing the tracking model on top of the sensory data.

III. RESULTS

A statistical summary of logs produced by experimental runs of the laboratory manufacturing system is given in Table 1. The total running time shown in the table reflects an average of about 30 min per run. Experimental runs consist of placing several orders to test the ability ofthe system to cope with customized demand, and then changing the orders to demonstrate its ability to react to a changed demand. As shown in the table, on average about 2000 objectmovements per run were detected (via RFID data) or inferred based on explicit control actions or implicit effects (such as items dropping down in a hopper). For each run, about 50 control actions (such as robotic movement of objects or monorail gate switch operations) were taken per run.

Figure 10.Work-in-process buffer for packing robot.

It is reasonably common for the system to receive a false positive RFID read in the work-in-process stack (two per run on average), since the WIP tag readers sometimes read the item second from the base of the stack as well as the item at the base. This leads to two items being considered to be at the base of the stack. Roughly half the time this is resolved when the probability estimate for one of the items reduces below a threshold (a value of 0.2 was used for this threshold) and is discarded. Since only a single item can fit at the base of the stack, the probability of an item being atthe base decreases when another item is detected there. In the rest of the cases, the uncertainty was removed after an action was taken to move the item at the base, and subsequently one of the items was detected elsewhere.

Total running time (min)	1649
Object movements detected or inferred	109366
Actions taken	2683
False positives in work-in-process stack	106
False positives pruned by probability threshold	51
False positives pruned after object movement	49
False negatives for shuttle corrected	41
False negatives for shuttle not corrected	2

Table 1. Accumulated results from 55 demonstration runs.

The two cases where this was not possible occurred when the shuttle tag was missed onthe first occasion that the aggregate was seen.

IV. CONCLUSION

RFID is a mature technology that is currently seeing a rise in prominence, largely due to its increased use in the retail sector. It has been applied to manufacturing, however it is mostly used as a means of establishing the genealogy or history of the end-product, rather than as a mechanism to support the automation of customizable production. However, increased consumer demand for customization may drive manufacturers to adopt RFID as a central part of the manufacturing control loop.

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