# 오도메트리 정보와 RFID 시스템을 이용한 이동 로봇 위치 인식 방법

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# New Algorithm of Localization Using Odometry and RFID System

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**Abstract** - Localization and its applications are very important area of the mobile robot technology. Especially, accurate localization is needed when we move the mobile robot to the goal position. In indoor cases, Global Positioning System(GPS) is not suitable but Radio Frequency Identification(RFID) technology can provide position data to the robot. A proposed algorithm in this paper uses not only odometry data but also RFID data to improve estimation of true position of the robot with the particle filtering.

## 1. Introduction

Localization is a crucial area of SLAM (Simultaneous Localization and Mapping) and it is an important issue for the mobile robot technology. When the mobile robot moves, usually the measurement position is different from the true position and this causes serious problems of moving the robot to the desired position.

To achieve the localization, various types of positioning technologies ar e developed. For example, the GPS (Global Positioning System) [1] and t he RFID (Radio Frequency Identification) [2] system provide absolute pos ition information independent of the robot moving. In indoor cases, the G PS is not suitable because it uses satellite signal which can be blocked by ceilings. Therefore an RFID system is widely used for the indoor loc alization.

RFID systems can be categorized by or types of RFID tags such as p assive and active type tags [2][3][4] or distribution of tags [5]. For man y types of RFID systems, tags and readers can provide position informat ion in a range manner.

In actual cases, estimation with odometry which measured at the objec t itself is not suitable to localization, and estimation using an RFID syst em requires many RFID tags for deriving better results.

The estimating of true positions of the robot is essential to perform lo calization; various types of filters are proposed and can be applied. For n onlinear systems, the particle filter [6] performs better than the kalman f ilter [7] and the extended kalman filter.

In this paper, we suggest an effective algorithm for estimating position o f the object with odometry [8] and RFID information. By the algorithm, we can achieve better position estimation and we might use less RFID t ags for same performance than algorithms which use only RFID informa tion.

## 2. System Model

We suggested a system model to estimate a position with odometry a nd RFID measurement information.

$$x(t+1)=f(x(t))+v_p$$
$$y(t)=h(x(t))+v_m$$

$x(t)$ is a state and $y(t)$ is a measurement. $f$ and $h$ represent a proc ess function and a measurement function. $v_p$ and $v_m$ indicate process a nd measurement noise. A system model might be nonlinear.

Odometry information from the object itself occur various errors such that wheel encoder error, wheel slip and etc. Furthermore the object can not avoid accumulative error of the true position. To overcome this char acteristic of the odometry, we use an RFID system for additional absolut e position information and to make the system model reasonable. An RFI D system provides absolute position range by reading tags with the read er on the object when the tags have unique IDs and position informatio n.

## 3. Using Particle Filter

With the provided system model, we can estimate the true position of the object. We use a particle filter to handle nonlinear system [9].
The particle filter proceeds from (t) to (t+1) in the following steps.
1) Initialization
2) Measurement Updating: Importance weighting
3) Resampling
4) Prediction

To control the object movement, the object can determine the next mo vement with the estimated position. Thus the object can move toward de sired position recursively.

## 4. Filter Modification Using RFID System

In this chapter, we suggest a modification of a particle filter with RFI D information to estimate the true position more precisely. As we mentio ned before, estimating the position with only odometry information is not reasonable to an actual system because of the characteristics of odometr y error. By using an RFID system, we can use the absolute position inf ormation; the true position can be estimated.

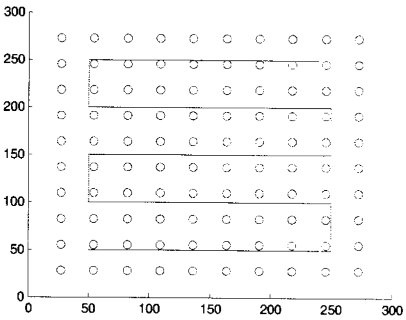
We assume properties of an RFID system:
1. An RFID tag responds to the object when the object is in the tag ran ge.
2. An RFID tag responds to the object by probability less than 100%.
3. An RFID tag has unique ID and absolute position information and tra nsmit them to the object

To improve filter estimation, we modify the importance weighting step of the particle filter with RFID position data. After obtaining RFID tag d ata around the object, check the particles are in the RFID range or not. If a particle is not in the range of any responded RFID tags, the weight for the particle reduces to 0. And if a particle is in a cross section of m ore than one responded RFID tag, we increase the weighting exponentiall y with arbitrary weight-rate. At this manner, the weight-rate must be l arger than 1.

```
Modified algorithm in particle filter
 2) Measurement Updating: importance weighting
  For each particle after calculating likelihood
  Loop for each responded RFID tag
        If  (the tag matched to the particle)
                matched_tag_count ++;
        End If
  End Loop
  If (matched_tag_count ==0)
        likelihood = 0;
  Else
        likelihood = likelihood * weight_rate ^ matched_tag_count
  End If
```

## 5. Simulation Result

In the simulation, an RFID system is constructed as a 2-dimensional gri d array of RFID tags and the object moves on the nonlinear track and r eads RFID tags for each time steps (Fig .1). A state consists of horizo ntal and vertical positions. And the initial position of the object is known and the desired positions for each time steps are fixed.

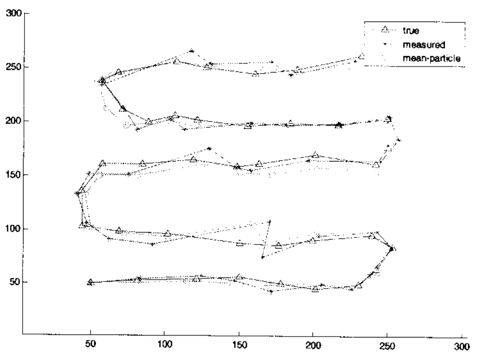



**<Figure 1> Simulation environment. Circles are RFID tags and line is the desired track of the object moving.**

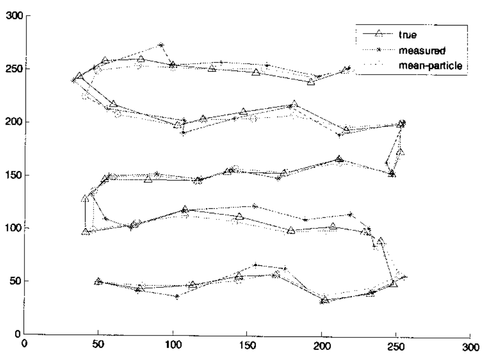
The simulation consists of two parts:
1) Estimation and control with only odometry information without RFID information (e. g. Fig. 2)
2) Estimation and control with odometry and RFID information (e. g. Fig. 3)
For the simulation of Fig. 2 and 3, the distribution of RFID tags is set up with 10 tags on each axis.

The result in Tab. 1 represents mean and variance values of root mean square error. Experiments are executed 100 times for having statistical meaningfulness because we set high process noise and measurement noise for simulations. The result using mixed data shows better performances of the proposed algorithm.

If distribution of RFID tags is denser, the performance is more enhanced and if distribution is too sparse, the performance is almost same as the result derived from simulation without RFID data (Tab. 2).




**<Figure 2> A simulation result without RFID data**
**Mean of root mean square error: x: 3.983 y: 4.256**
**Variance of root mean square error: x: 11.917 y: 14.026**




**<Figure 3> A simulation result with RFID data**
**Mean of root mean square error: x: 2.428 y: 4.025**
**Variance of root mean square error: x: 4.407 y: 12.867**
**(x: x direction, y: y direction)**

**<Table 1> Root mean square errors (true position-estimation) with 10 tags on each axis**

| | x direction | | y direction | |
|---|---|---|---|---|
| | mean | var | mean | var |
| without RFID data | 4.58 | 13.72 | 4.61 | 14.50 |
| with RFID data | 4.16 | 12.12 | 4.34 | 12.32 |

**<Table 2> Root mean square errors (true position-estimation) with changing distribution of RFID tags**

| | x direction | | y direction | |
|---|---|---|---|---|
| tags on x, y axis | mean | var | mean | var |
| 6 | 4.46 | 13.74 | 4.36 | 15.44 |
| 8 | 4.28 | 12.46 | 4.1 | 11.29 |
| 10 | 4.16 | 12.12 | 4.34 | 12.32 |
| 12 | 4.03 | 11 | 3.91 | 10.35 |
| 14 | 3.73 | 10.2 | 3.74 | 10.51 |
| 16 | 3.68 | 10.23 | 3.61 | 11.84 |
| 18 | 3.76 | 11.15 | 3.86 | 11.28 |
| 20 | 3.7 | 10.6 | 3.78 | 11.12 |

## 6. Conclusion

This paper proposed an algorithm for localization by estimating object position with odometry data in RFID system. The algorithm uses odometry information even it is very noisy; we can achieve better position estimation with RFID tags. In other words, we might use less RFID tags for same performance than algorithms which use only RFID data.


## Acknowledgement

This research was supported by Ministry of Knowledge and Economy, Republic of Korea, under the ITRC (Information Technology Research Center ) support program supervised by IITA(Institute for Information Technology Advancement) (IITA-2008-C1090-0801-0004).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