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Abstract

We have developed a weeding robot(Aigamo Robot). This robot works automatically using Global Navigation Satellite System (GNSS). Previous independent positioning measure included several meter differences and dispersion of the positions and directions. Therefore, in this study, we implement the Real Time Kinematic-GNSS (RTK-GNSS) on the right and left side of the robot in order to reduce these errors. T his method can obtain the position and direction more acculately when the robot is not only in operation, but also under suspending. Moreover, this method can suppress the errors within about 10 cm to the south-southeast when the path tracking.

1 Introduction

Our research group has been developed a small weeding robot[1]. This robot weeds automatically in paddy fields. It is important for the robot to know the self-position because it moves in a vast environment. To know the self-position, some researchers use camera[2] or beacon[3]. However, these devices easily affected by disturbance such as weather, so it is difficult to apply to our robot. Therefore, we adopt Global Navigation Satellite System(GNSS) to obtain self-position of the robot. Conventionally, robots obtain self-position by single-positioning method. However, position errors and orientation errors are greatly increase. Therefore, we adopt Real Time Kinematic-GNSS (RTK-GNSS) for higher accuracy. GNSS modules mainly receive two kinds of carries. Dual frequency receivers are expensive and large, so we can not mount our robot. On the other hand, the number of satellites has increased by multi-GNSS technology in recent years. As a result, cheap and compact modules that can acquire one frequency carrier have been on the market. Therefore, we adopt these modules. We installed two modules on the both side of the robot because it is difficult to estimate the orientation of the robot using only one module. In this research, we propose a more accurate self-localization system by introducing the Kalman filter into our positioning system. We verify our proposed method by Matlab.

2 カルマンフィルタの説明

この章では提案するカルマンフィルタのモデルを説明をする．本研究ではアイガモロボットを対象としており，このロボットは２次元平面上を移動する．カルマンフィルタの予測フェーズ

$$\begin{aligned}\hat{x}_{t+\Delta t|t} &= F_t\hat{x}_t + B_t u_t \\ &= \hat{x}_t + B_t u_t\end{aligned} \tag{1}$$

$$\begin{aligned}\hat{P}_{t+\Delta t|t} &= F_t P_{t|t} F_t^T + Q \\ &= P_{t|t} + Q\end{aligned} \tag{2}$$

$$\begin{bmatrix}\hat{x}_{t+\Delta t|t} \\ \hat{y}_{t+\Delta t|t} \\ \hat{\theta}_{t+\Delta t|t}\end{bmatrix} = \begin{bmatrix}\hat{x}_{t|t} \\ \hat{y}_{t|t} \\ \hat{\theta}_{t|t}\end{bmatrix} + \begin{bmatrix}\Delta t cos\hat{\theta}_{t|t} & 0 \\ \Delta t sin\hat{\theta}_{t|t} & 0 \\ 0 & \Delta t\end{bmatrix} \begin{bmatrix}v_t \\ \omega_t\end{bmatrix} \tag{3}$$

$$e_t = \hat{x}_t - x_t = \begin{bmatrix}\hat{x}_t - x_t \\ \hat{y}_t - y_t \\ \hat{\theta}_t - \theta_t\end{bmatrix} \tag{4}$$

$$P_{t|t} = E\left(e_t e_t^T\right) \tag{5}$$

$$\begin{aligned}&\begin{bmatrix}\sigma_{xx,t|t+\Delta t} & \sigma_{xy,t|t+\Delta t} & \sigma_{xz,t|t+\Delta t} \\ \sigma_{yx,t|t+\Delta t} & \sigma_{yy,t|t+\Delta t} & \sigma_{yz,t|t+\Delta t} \\ \sigma_{zx,t|t+\Delta t} & \sigma_{zy,t|t+\Delta t} & \sigma_{zz,t|t+\Delta t}\end{bmatrix} \\ &= \begin{bmatrix}\sigma_{xx,t|t} & \sigma_{xy,t|t} & \sigma_{xz,t|t} \\ \sigma_{yx,t|t} & \sigma_{yy,t|t} & \sigma_{yz,t|t} \\ \sigma_{zx,t|t} & \sigma_{zy,t|t} & \sigma_{zz,t|t}\end{bmatrix} + \begin{bmatrix}q_x^2 & 0 & 0 \\ 0 & q_y^2 & 0 \\ 0 & 0 & q_\theta^2\end{bmatrix}\end{aligned} \tag{6}$$

カルマンフィルタの更新フェーズ

$$y_t = z_t - H_t\hat{x}_{t+\Delta t|t} \tag{7}$$

$$S_t = R + H_t P_{t+\Delta t|t} H_t^T \tag{8}$$

$$\hat{x}_{t+\Delta t|t+\Delta t} = x_{t+\Delta t|t+\Delta t} \tag{9}$$

3 カルマンフィルタに用いる分散の取得実験

Regarding the styles of your manuscript, please conform to the following

3.1 Title

The title should be centered across the top of the first page and should be in a distinctive point size or font.

3.2 Author's Names and Address

The authors' names and addresses should be centered below the title. It is desirable that these lines are typed in at least eleven point font size, but the particular point sizes and fonts are not critical and are left to the direction of the authors. Times new Roman 12 point is suggested. Please include your E-Mail address.

3.3 Headings

Main headings are to be column centered in a bold font without an underline. They may be numbered, if so desired.

Subheadings should be in a bold font or underlined lowercase with initial capitals. They should start at the left-hand margin on a separate line.

Sub-subheadings are to be in a bold font or underlined type. They should be indented and run in at the beginning of the paragraph.

3.4 Figures and Tables

Figures and photos should be consecutively numbered like Fig. 1, Fig. 2, Figures should be inserted near their citation or at the end of the manuscript. Large figures and tables may span across both columns if necessary. Figure captions should be placed below the figures.

3.5 References

List and number all references at the end of the paper as shown below. Number reference citations consecutively in square brackets [1].

3.6 Page Numbers

Do not write page numbers on your manuscript. These will be inserted later by the proceedings printer together with the session number and conference identifications.

4 Manuscript Submission

Authors are requested to send their manuscripts electronically by **July 31, 2018** on the web:

http://sci-sss.org/sss2018/sub/submission.php

5 Conclusions

Please make an extra effort to adhere to these guidelines as the quality of the publications depends on you. Thank you for your cooperation and contribution. We are looking forward to seeing you at the 49th ISCIE International Symposium on Stochastic Systems Theory and Its Applications (SSS'17).

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