Direction Control of Moving Vehicle using Dual RTK-GNSS and Kalman Filter

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Abstract

We have been investing a weeding robot. The robot estimates its position with Global Navigation Satellite System(GNSS) but includes errors, which are around a few meters, when it does single positioning. The direction of the robot deviates a lot as it is based on location information. Hence by using the more accurate Real Time Kinematic GNSS (RTK-GNSS), the positional accuracy improved. However, since the direction of the robot was estimated from the difference with the position of the previous robot, it was difficult to estimate the direction while posing. Therefore, we presumed self-position with two single frequency RTK-GNSS receivers which become to be available recently and are economically friendly. By setting the normal vector calculated from the left and right position information with two modules as the direction of the robot, it made it possible to estimate the direction not only while running but also posing. Moreover, we will tackle construction of position estimation system with Kalman filter.

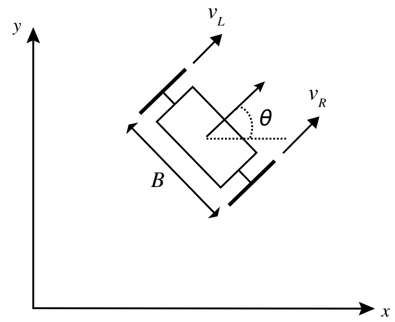

Fig. 1: Robot model

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

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

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

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

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

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

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

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

4 Simulation using Kalman filter

Table 1: Parameters for simulation

Parameter	Value
車輪間距離 B	$0.35[m]$
左車輪速度 v_L	$0.2[m/s]$
右車輪速度 v_R	$0.3[m/s]$
ロボットの制御周波数	$100[Hz]$
GNSS の更新周波数	$5[Hz]$

4.1 Result

4.2 Disucussion

5 Conclusions

References

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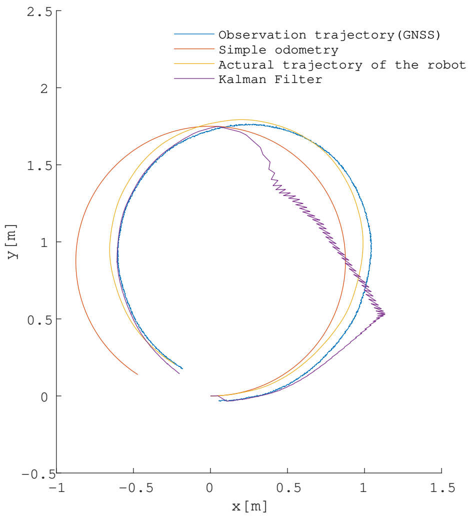

Fig. 2: Small process noise

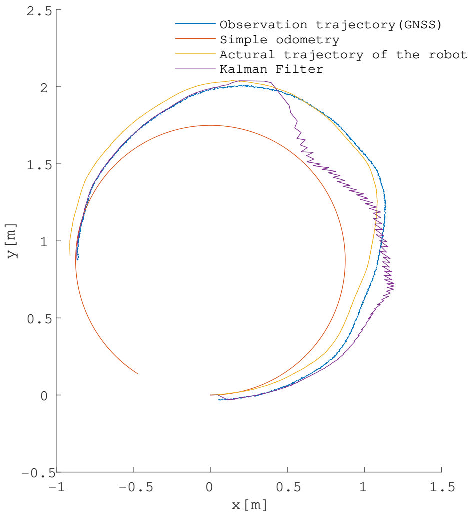

Fig. 3: Middle process noise

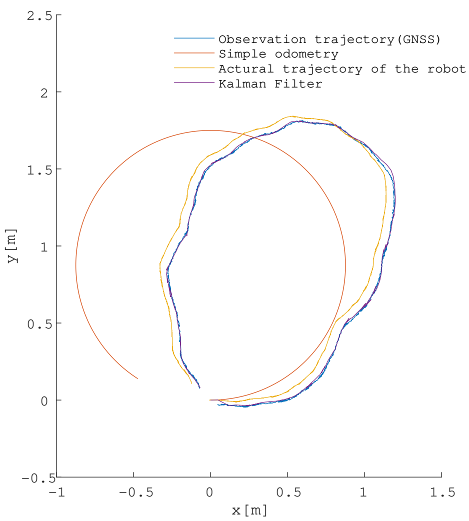

Fig. 4: Large process noise

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