

# Prediction of Tractor Behavior based on Reconstructed Terrain Profiles Using Stereo- vision Camera

愼, 素煥

<https://hdl.handle.net/2324/4110557>

---

出版情報：九州大学, 2020, 博士（農学）, 課程博士  
バージョン：  
権利関係：



氏 名 : Shin Soyoung

論文題名 : Prediction of Tractor Behavior based on Reconstructed Terrain Profiles  
Using Stereo-vision Camera

(ステレオビジョンカメラによる再構成路面情報に基づくトラクタの挙動予測)

区 分 : 甲

## 論 文 内 容 の 要 旨

With the decrease in agricultural population and the increase in large-scale farmland, the use of agricultural machinery is indispensable, therefore, a research on improving the safety of agricultural machinery is required. In particular, tractor rollover accident, which suffered the most casualties, is one of the most attracting problems. Tractors with a high center of gravity compared to other vehicles are easily exposed to the risk of tipping over. Furthermore, tractors that mainly drive on uneven roads have a very high risk of overturning. The tractor overturn accident is affected by various factors such as whether the implements are attached, the location of the attached implements, the soil condition, and the operation speed.

Statistically, the tractor rollover accident was about 75-85% of the side rollover, and it was found that the tractor mainly occurred on uneven sloped roads. A number of prominent research observed basic phenomena and defined fundamental theories on tractor rollover. In order to reduce the human injury caused by rollover, the rollover protective structure(ROPS) was designed and developed. ROPS was able to reduce fatalities by protecting the space in the driver's seat when a tractor rollover occurred. However, ROPS does not prevent actual accidents. In order to replace this passive method, theoretical mathematical modelling of the tractor behaviour characteristics, ground characteristics, and vehicle stability has been developed. By using models of physically static, semi-static, and dynamic states, the characteristics of the tractor can be considered when driving. The tractor's mathematical modelling was used to develop the tractor's safety indicators. Several research derived equations of up and down, pitching, rolling, and forward and backward motions of tractors driving on inclined terrain, and simulated tractor motion on the actual form of rollover accidents site. In this study, we aim to predict the correct behavior based on the tractor dynamics model, consider to establish early roll behavior prediction system when operating on roads and bumps using the tractor angular velocity. Moreover, for the purpose of indicating the actual condition of the tractor driving on the road surface, the estimation of the state was performed with the extended Kalman filter between the simulation values and measured values. In order to effectively prevent the tractor from tipping over, it is important to confirm the predicted rollover before the tractor actually drives upcoming road. In this study, the stereo-vision camera installed on the tractor reconstructs the front ground of the tractor in three dimensions and the reconstructed ground information entered into the tractor motion model to predict the tractor's rollover. The same ground taken from different angles can be reconstructed in three dimensions. Using the stereo-vision camera on this principle, it is possible to obtain reliable three-dimensional data with paired two-dimensional images. The distance to the target object can be identified by collecting 3D data. 3D reconstruction using stereo-vision becomes attractive method to providing adequate details. Through this, in agriculture field, stereo-vision camera adopted to the crop harvesting robots, and it is mainly used to grasp the growth status of indoor cultivated crops and observe obstacles. A study was also conducted to establish a

machine stop system for preventing a safety accident when a person or obstacle is predicted by estimating the situation ahead using a stereo-vision camera.

Chapter 2 presents the study on the terrain reconstruction using stereo-vision camera. A fundamental knowledge of stereoscopic was introduced, and the usefulness of stereo-vision camera for terrain reconstruction was evaluated in this chapter. The reconstructed grounds with the stereo-vision camera were investigated, and the 3D reconstruction of the stereo vision camera to which the gimbal system was applied was compared the error level.

Chapter 3 describes the behaviour model of the tractor driving the slope and the key assumptions employed to derive the model. Based on the derived equations of motion, we introduced the existing programs developed using Matlab/Simulink. Using the simulation model, each result when driving on the reconstructed ground was investigated and the usefulness of the model was considered.

In Chapter 4, the extended Kalman filter was introduced and the application of the Extended Kalman filter to improve simulation accuracy was investigated. This chapter will introduce an improvement in the accuracy of model estimation and model estimation by filtering using the estimated value by the model and the measured value of the angular velocity obtained from the inertial sensor.

The major results and implications of this study are summarized in Chapter 5.