



Percy Wilianson Lovon Ramos

**Modeling and Control Design of a Tracked
Mobile Robot for Surveillance Tasks**

Dissertação de Mestrado

Dissertation presented to the Programa de Pós-graduação em Engenharia Elétrica da PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Engenharia Elétrica

Advisor: Prof. Antonio Candea Leite

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Abstract

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In recent years, the latest advances in robotics and its applications have been used to reduce the workload and manpower requirements, improving the environment, health and safety (EHS) conditions, particularly in agricultural production and farming systems. Autonomous robots are part of such technological innovation and Tracked Mobile Robots (TMRs), in particular, have been widely used on agricultural fields around the world, since their tracks provide a large contact area on the wet soils and irregular terrains avoiding the robot to get stuck. In this work, we address the modeling and control design of tracked mobile robots (TMRs) able to perform surveillance tasks in agricultural fields. The proposed methodology considers that the kinematic models of the TMRs are both uncertain due to the inherent slippage between the tracks and the terrain. To deal with the modeling uncertainties and external disturbances, we use the sliding mode control (SMC) approach. A Mobile User Interface (MUI) based on Android operating system, is developed to control the TMR manually or autonomously. By using the MUI the human operator can visualize the information captured from external and internal sensors. Numerical simulations in MATLAB are carried out to verify the performance of the controller as well as validate the robot kinematic model under different configurations.

Keywords

Tracked Mobile Robots; Robust Control; Uncertain Systems; Mobile User Interface; Surveillance Robots;

Resumo

Lovon Ramos, Percy Wilianson; Leite, Antonio Candea. **Modelagem e Controle de um Robô Móvel com Esteiras para Tarefas de Vigilância**. Rio de Janeiro, 2019. 118p. Dissertação de Mestrado – Departamento de Engenharia Elétrica, Pontifícia Universidade Católica do Rio de Janeiro.

Nos últimos anos, os avanços mais recentes em robótica e suas aplicações têm sido usados para reduzir a carga de trabalho e os requisitos de mão-de-obra, melhorando o ambiente, a saúde e a segurança, particularmente nos sistemas de produção agrícola. Robôs autônomos fazem parte de tal inovação tecnológica e os robôs móveis com esteiras, em particular, têm sido amplamente utilizados em campos agrícolas em todo o mundo, já que suas esteiras proporcionam uma grande área de contato em solos úmidos e terrenos irregulares, evitando que o robô fique preso e melhorando a sua mobilidade. Neste trabalho, aborda-se a modelagem e o controle de robôs móveis com esteiras (*Tracked Mobile Robots, TMRs*) para executar tarefas de vigilância em campos agrícolas. A metodologia proposta considera que o modelo cinemático do TMR são incertos devido ao escorregamento inerente entre as esteiras e o terreno. Para lidar com as incertezas de modelagem e perturbações externas, utiliza-se uma estratégia de controle robusto baseada na abordagem de modos deslizantes. Uma interface de usuário móvel (*Mobile User Interface, MUI*) baseada no sistema operacional Android é desenvolvida para controlar o robô móvel com esteiras de forma manual ou autônoma. A partir da MUI, o operador humano pode visualizar as informações capturadas de sensores externos e internos. Simulações numéricas em MATLAB são realizadas para verificar o desempenho dos controladores, bem como validar o modelo cinemático do robô, em diferentes configurações iniciais.

Palavras-chave

Robôs Móveis com Esteiras; Controle Robusto; Sistemas Incertos; Interface de Usuário Móvel; Robôs de Vigilância;

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List of Abbreviations

CCTV – Closed Circuit Television
DTFM – Dual Tone Multifrequency
GPS – Global Position System
HRI – Human Robot Interaction
ICR – Instantaneous Center of Rotation
ID – Identification
IMU – Inertial Measurement Unit
IoT – Internet of Things
IP – Internet Protocol
LIDAR – Laser Imaging Detection and Ranging
MUI – Mobile User Interface
OS – Operating System
PIR – Passive Infrared sensor
RGB-D – Red Green Blue-Depth
RHIB –Rigid Hull Inflatable Boat
ROS – Robot Operating System
SAR – Synthetic Aperture Radar
SBSS – Space Based Space Surveillance
SMC – Sliding Mode Control
STA – Super Twisting Algorithm
TMR – Tracked Mobile Robot
UUV – Unmanned Underwater Vehicles
WMR – Wheeled Mobile Robot

Science without religion is lame, religion without science is blind.

Albert Einstein, *Science and religion*, 1954.