Autonomous Navigation of a Forestry Robot Equipped with a Scanning Laser

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Outline

PIF Project

Innovative Forest Plantations

PIF

Working group 1 : Association

- Inform the public about forestry and planting issues
- Achieve consensus on social expectations and planting practices

Working group 3 : Environmentalist

- Evaluate the environnement impacts practices
- Improve soil and biodiversity conservation

Working group 2 : Engineering

- Automation of specific operation (weeding plant)
- Improve the ergonomics, tools and planting practices

PIF-Working Group 2

Objectif of PIF- Working Group 2

The project concerns the automation of maintenance tasks for poplar plantations in the first years after planting, in particular mechanical weeding without the use of herbicides.

- Remove competing vegetation around the tree trunk (localized soil work)
- A mini-excavator with extra-wide track pads delivers extremely low ground pressure

FIGURE 1 – witness plant/weeding plant (FACB results 25/08/2021)

FIGURE 2 – Mechanical weeding

Problematic : Environment Constraint

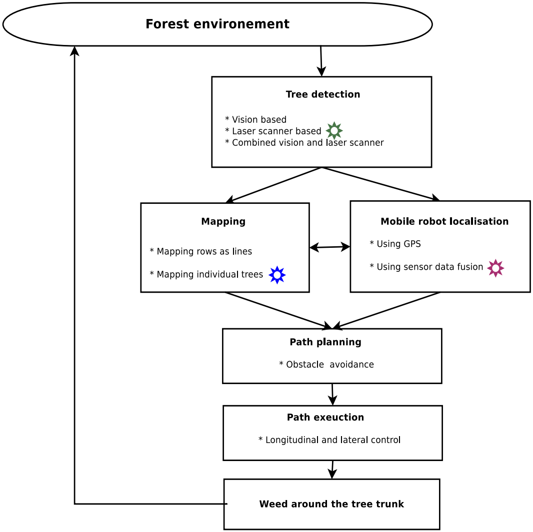
⇒ The camera contrast depend on light condition : Sunny/Clouded days

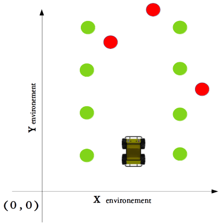
⇒ The risk that the vehicle skip in an irregular terrain (wet condition, slope)

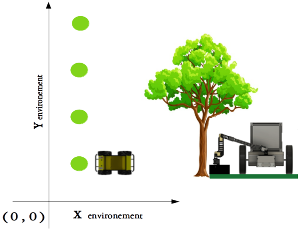
⇒ The GPS signal can degraded at the ground level due to tree canopy

⇒ The robot have to avoid obstacles (stump,..)

Technical Solutions for Forest Environment







Prototype : Mobile Robot Husky A200TM

Husky A200TM : out-door mobile robot developed by Clearpath, Canada

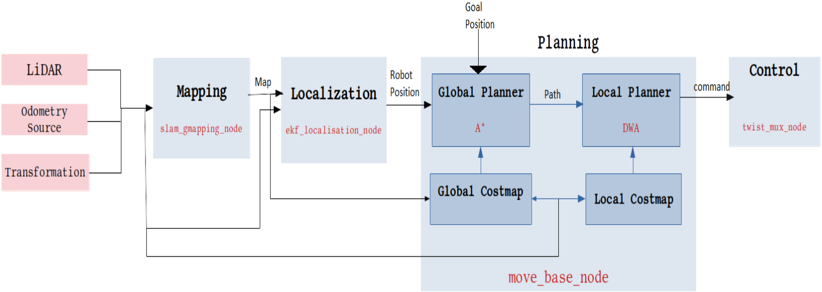
- Husky use an open source protocol (ROS : Robot Operating System)
- Husky can communicate with others manipulator (weed tools)
- Husky present a good compromise quality/price

FIGURE 3 – Clearpath mobile robot Husky A200TM

Technical characteristic	
Dimensions	$990 \times 670 \times 390$ mm
Weight	50 kg
Wheels	330 mm
Maximal load	75 kg
Load in irregular terrain	20 kg
Maximal velocity	1 m/s
Transmission	4×4 driven wheel
Maximal slop	$45°$
Driver	ROS, C^{++}, Python

Challenge 1 : Robot Navigation

To perform autonomous navigation, four main modules are required : mapping, localization, planning, control



- source : http ://wiki.ros.org/move-base
- source : http ://wiki.ros.org/gmapping

Simulation Results : Robot Navigation

For ROS simulation, three packages are used :

(1) **husky-gazebo :** 3D simulator

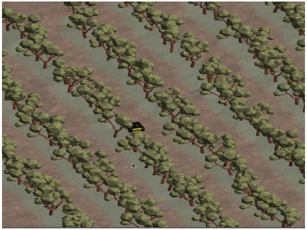
(2) **husky-viz :**

- to visualize sensor data
- to supervise the robot's movement

(3) **husky-navigation :**

- *move-base.launch :* to track path and execute tasks (node : *move-base.cpp*)
- *gmapping.launch :* to create a 2D occupancy grid from laser data and odometer (node : *slam-gmapping.cpp*)

source : Clearpathrobotics. husky 2020. Available from : https ://github.com/husky/husky



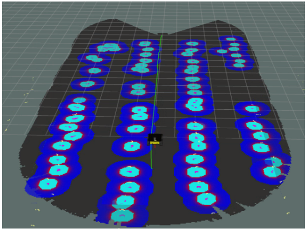
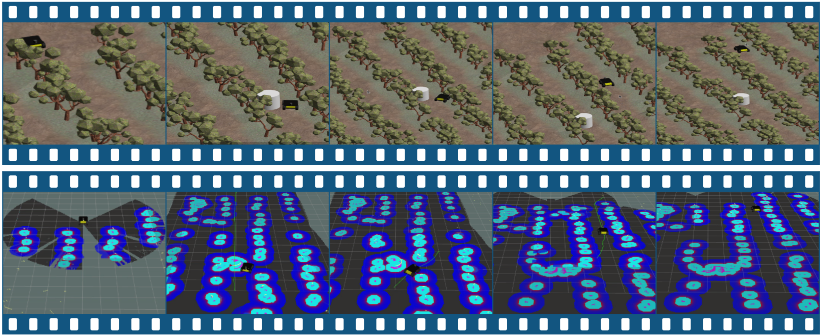


FIGURE 4 – Gazebo and Rviz visualization

Simulation Results : Tree Detection Using 2D LiDAR

The **simulation** highlights the robot's ability to :

- Detect individual trees *(2D mapping)*
- Obstacle avoidance *(Frame* 1*)*
- Move between the two trees *(Frame* 2*)*



Frame 0 Frame 1 Frame 2 Frame 3 Frame 4

⇒ We can not make the difference between a tree and other obstacles (stump, fern and bramble plants, ...)

LeGO-LOAM and LIO-SAM Algorithm : 3D Detection

To perform real-time pose estimation for UGVs in complex environment, a LeGO-LOAM method is proposed by Shan

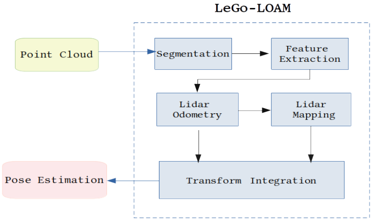


FIGURE 5 – System overview of LeGo-LOAM, source : Tixiao Shan et al, Lightweight and Ground-Optimized Lidar Odometry and Mapping on Variable Terrain, IROS 2018

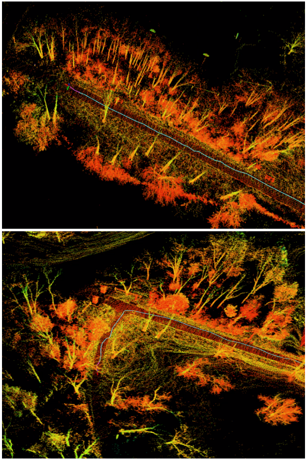


FIGURE 6 – LIO-SAM mapping result(park-dataset-003.bag)

The LIO-SAM method is recently proposed by Shan and it is more accurate than LeGO-LOAM

source : Tixiao Shan. LIO-SAM. 2020. Available from : https ://github.com/TixiaoShan/LIO-SAM

Conclusions and Perspectives

Conclusions :

(1) **Investigating forest environmental constraints** (visit of forestry sites in France)

(2) **Identification of technical specifications and sensor selection**

(3) **Implementation of control, localization and mapping algorithms in numerical simulation** (using the middleware ROS)

Perspectives :

(1) **Develop a prototype** (Robot platform Husky equipped with sensors)

(2) **Explore the possibility of extending the project to other applications** (forest inventory, olive tree orchard, ...)

FIGURE 7 – Possible applications of forestry robot

THANK YOU FOR YOUR ATTENTION

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