Control of a fleet of heterogeneous autonomous vehicles in off-road conditions

Audrey GUILLET

Irstea – Clermont-Ferrand - France

Introduction

Objective : Servo the positioning of a robot with respect to a trajectory and other robots in a formation configuration





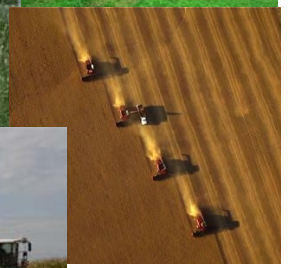




Robotic fleet devices have to meet task expectations...

- Preserve repeatability
- Ensure a high level of accuracy
- Preserve its integrity and safety
- Have to be adaptable (variable shape)





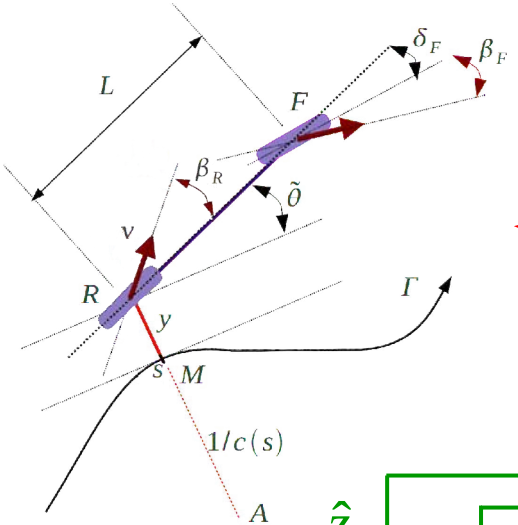

.... despite harsh and variable off-road conditions

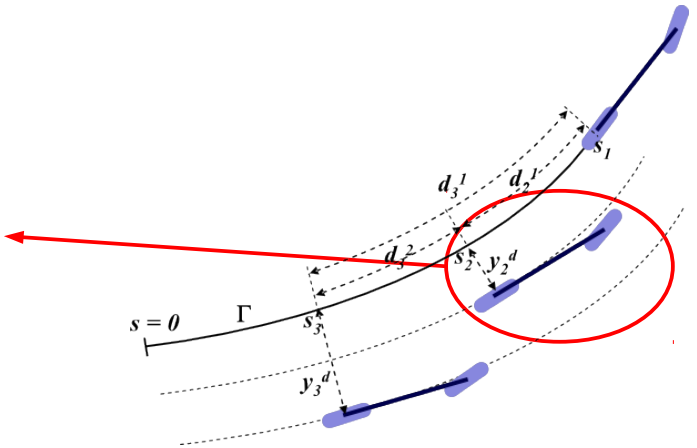

Work frame

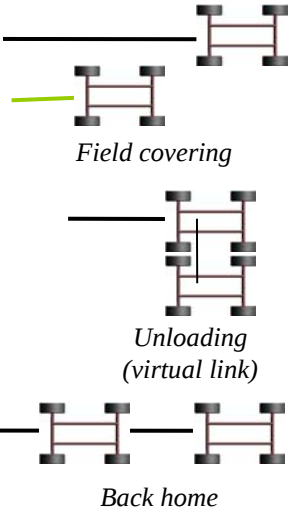
- Trajectory is known
- Decentralized control of the fleet
- WiFi communication module between robots

Global algorithm for the control of a robot maintaining a formation in off-road conditions

1 Definition of a model of the robots in a formation configuration







$\hat{Z}$

Model with sliding

$X_{Obs} = f_{Obs}(X_{Obs}, u_{Obs})$

Reference

Leader Data

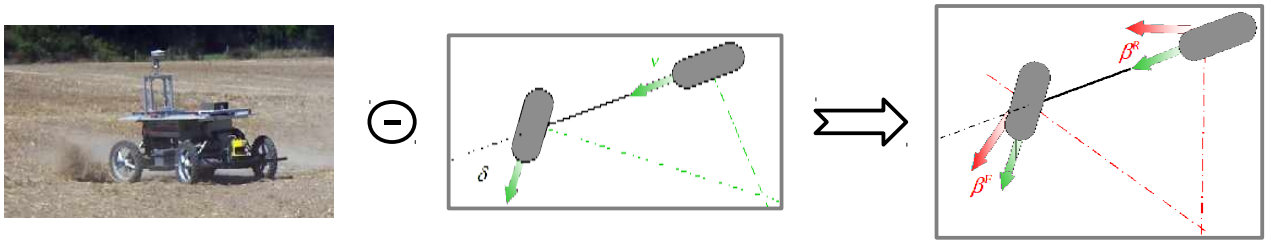
Sensors :
- RTK-GPS
- IMU
- Odometry

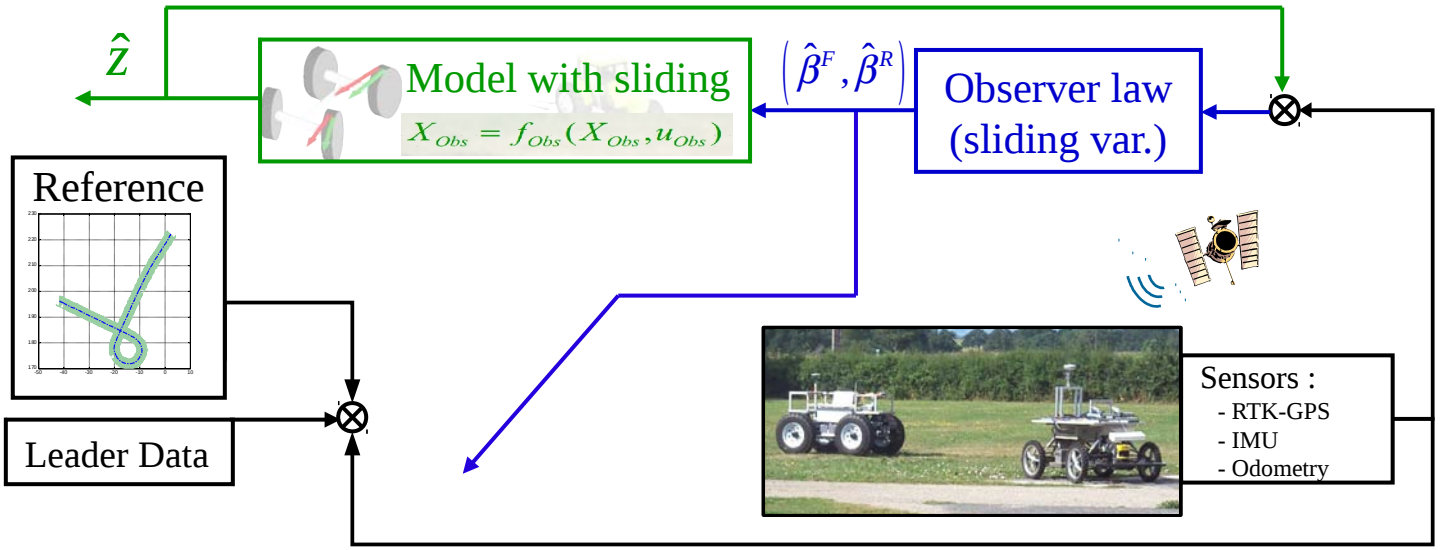
Global algorithm for the control of a robot maintaining a formation in off-road conditions

1 **Definition of a model of the robots in a formation configuration**

2 **Estimation of sliding via an observer-like algorithm**

Hyp: differences between actual process and model without sliding are mainly due to sliding effects





Global algorithm for the control of a robot maintaining a formation in off-road conditions

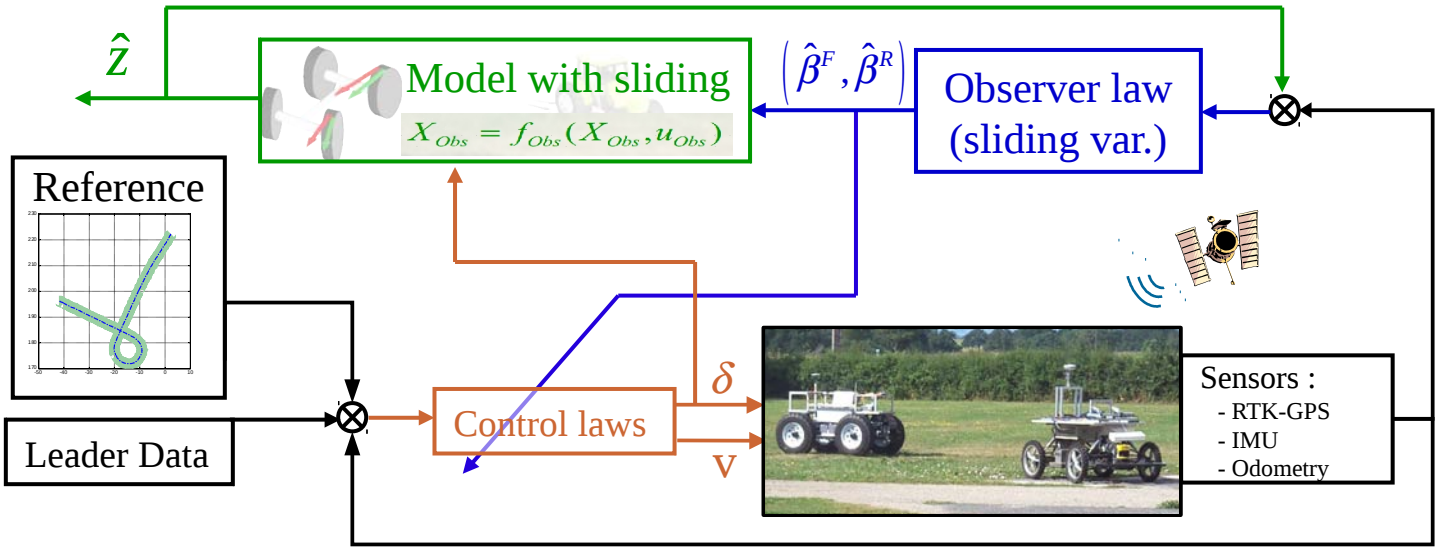
1 **Definition of a model of the robots in a formation configuration**

2 **Estimation of sliding via an observer-like algorithm**

3 **Control laws on velocity and steering angle to respect a formation configuration**

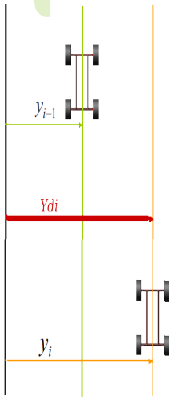
- 3.1 **Adaptative control laws** — Compensation of the positionning errors and skidding
- 3.2 **Partial prediction on the steering control**
- 3.3 **Prediction on the velocity control**

Anticipation of the real behavior of the robot (settling time of the motors)



Control laws on steering angle and velocity

- Predicted positions of both robot *i* and leader robot, from current positions and velocities: $s(t+t_h)=s(t)+t_h.\dot{s}(t)$



- Lateral control

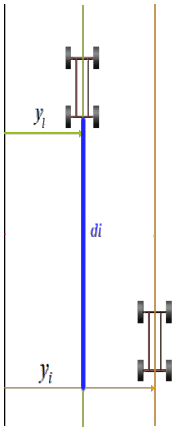
  Control of the steering angle δ_i of the robot for the convergence of the lateral deviation y_i to the desired value y_i^d.

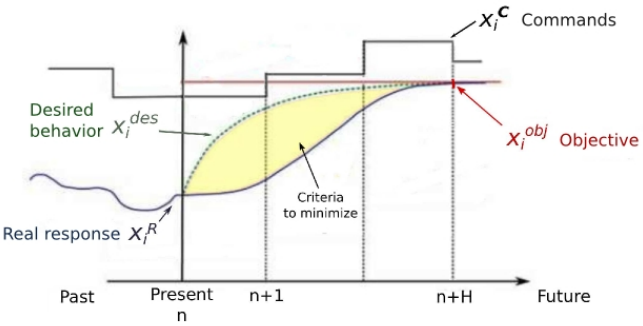
Steering angle objective anticipates for the future curvature of the path

- Longitudinal control

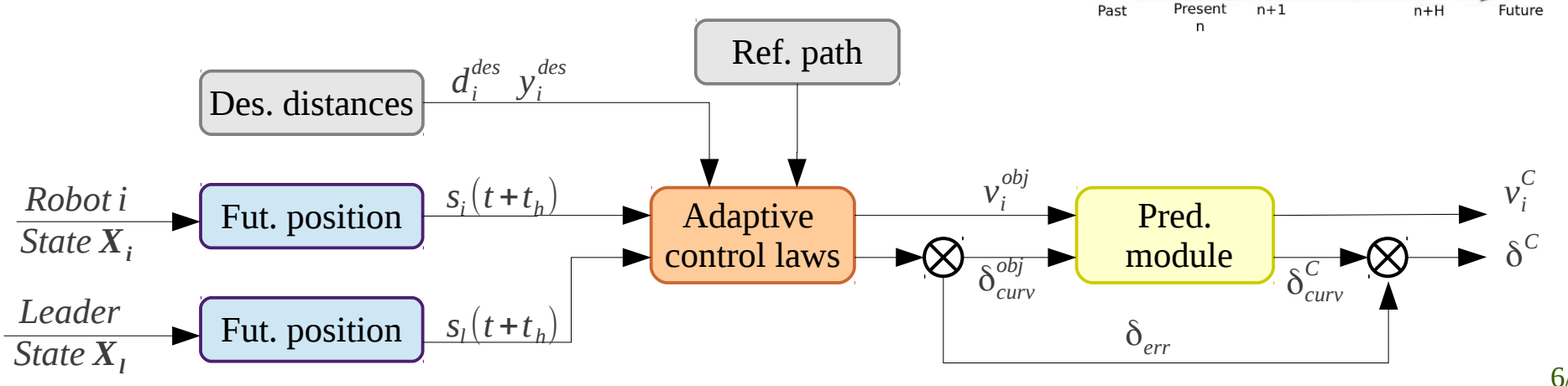
  Derivation of the objective velocity so that the future position of the robot converges to the desired interdistance d_i wrt the leader

$v_i^{obj} = function(s_i(t+t_h),\ s_l(t+t_h),\ ...)$



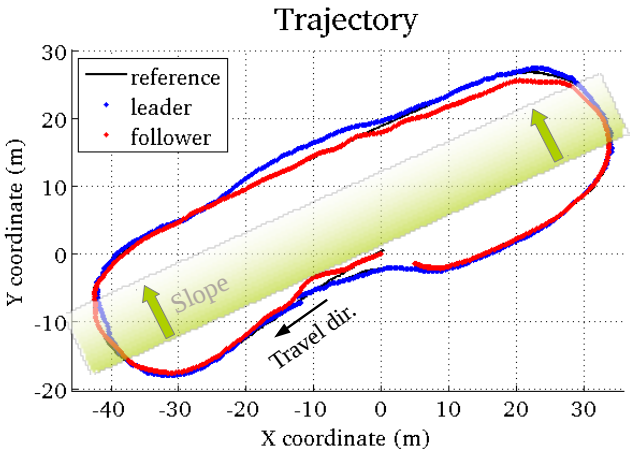


- Calculation of the optimal sequence of controls, knowing actuators properties



Experimental results using 2 vehicles

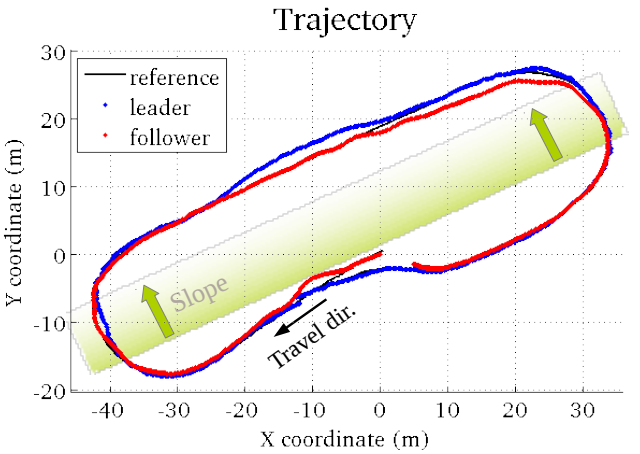
- Path tracking of a previously known trajectory
- Leader velocity: 2 m/s
- Variable desired distances

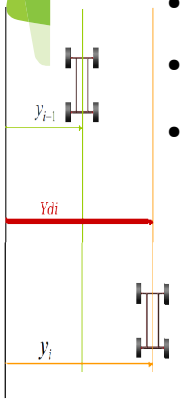


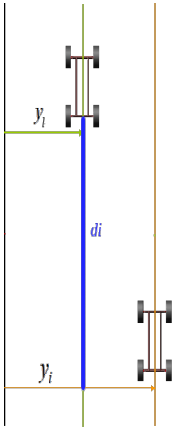
Video

Experimental results

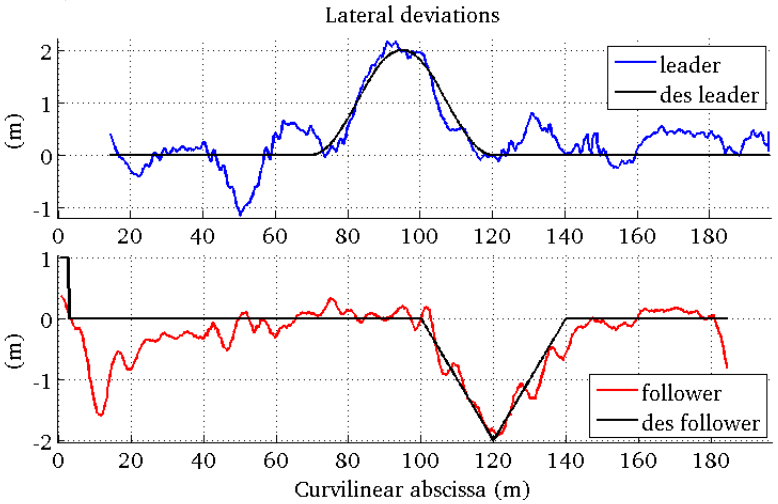
- Path tracking of a previously known trajectory
- Leader velocity: 2 m/s
- Variable desired distances



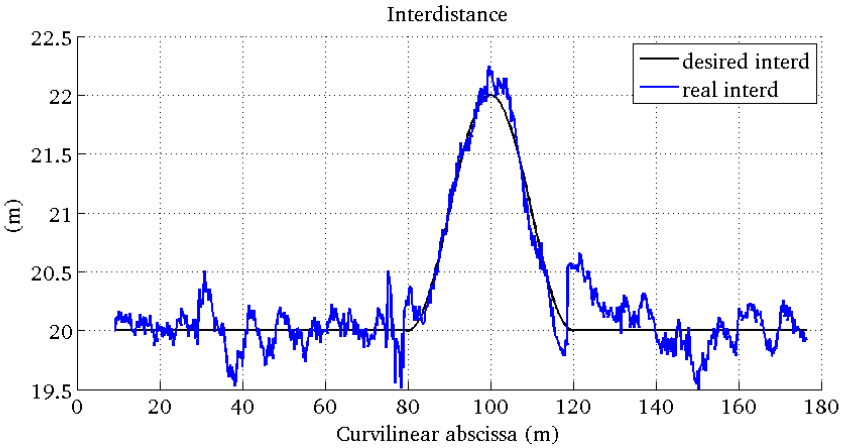




Lateral regulation



Longitudinal regulation



Account for bad grip conditions and slope

Good anticipation of the variations with prediction control

Standard deviations : for lateral control : 0,26 m for the tractor
0,17 m for the robot
for longitudinal control : 0,18 m

Questions ?

3-vehicle formation with manual leader

Maneuver handling