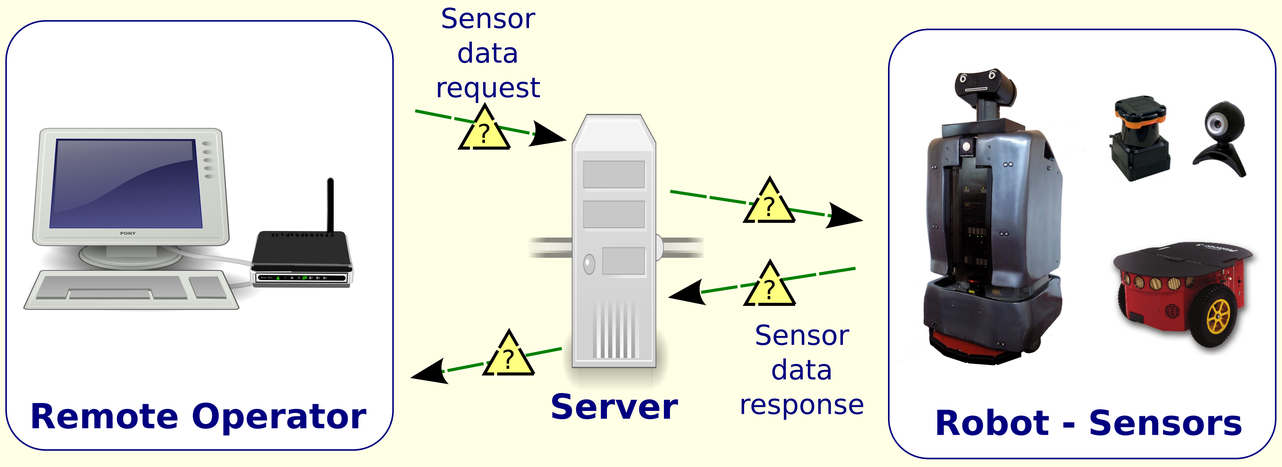
Hierarchical Regulation of Sensor Data Transmission for Networked Telerobots

Ángel Martínez-Tenor, Ana Gago-Benítez, Juan-Antonio Fernández-Madrigal, Ana Cruz-Martín, Rafael Asenjo and Ángeles Navarro

Systems Engineering and Automation Dpt.
University of Málaga (Spain), Andalucia Tech

IEEE SENSORS 2014
Valencia Conference Centre • Valencia, Spain • November 2-5, 2014
Conference: November 3-5, 2014 • Tutorials: November 2, 2014

PROBLEM STATEMENT



⚠ Stochastic transmision times prevent proper execution of some real-time control tasks (e.g. navigation)

GOAL: Regulate Sensory information to:

- Maximise the number of sensors transmitting
- Maximise the amount of transmitted data
- Prioritize the essential sensors for the task
- Guarantee soft (statistical) real-time

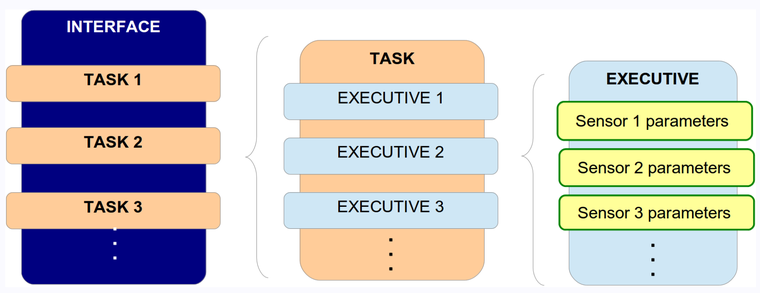
APPROACH

2-level Hierarchical Controller

Implemented in a portable Web-based Teleoperator Interface

Coarse regulation: activation / deactivation of sensors

Top Level

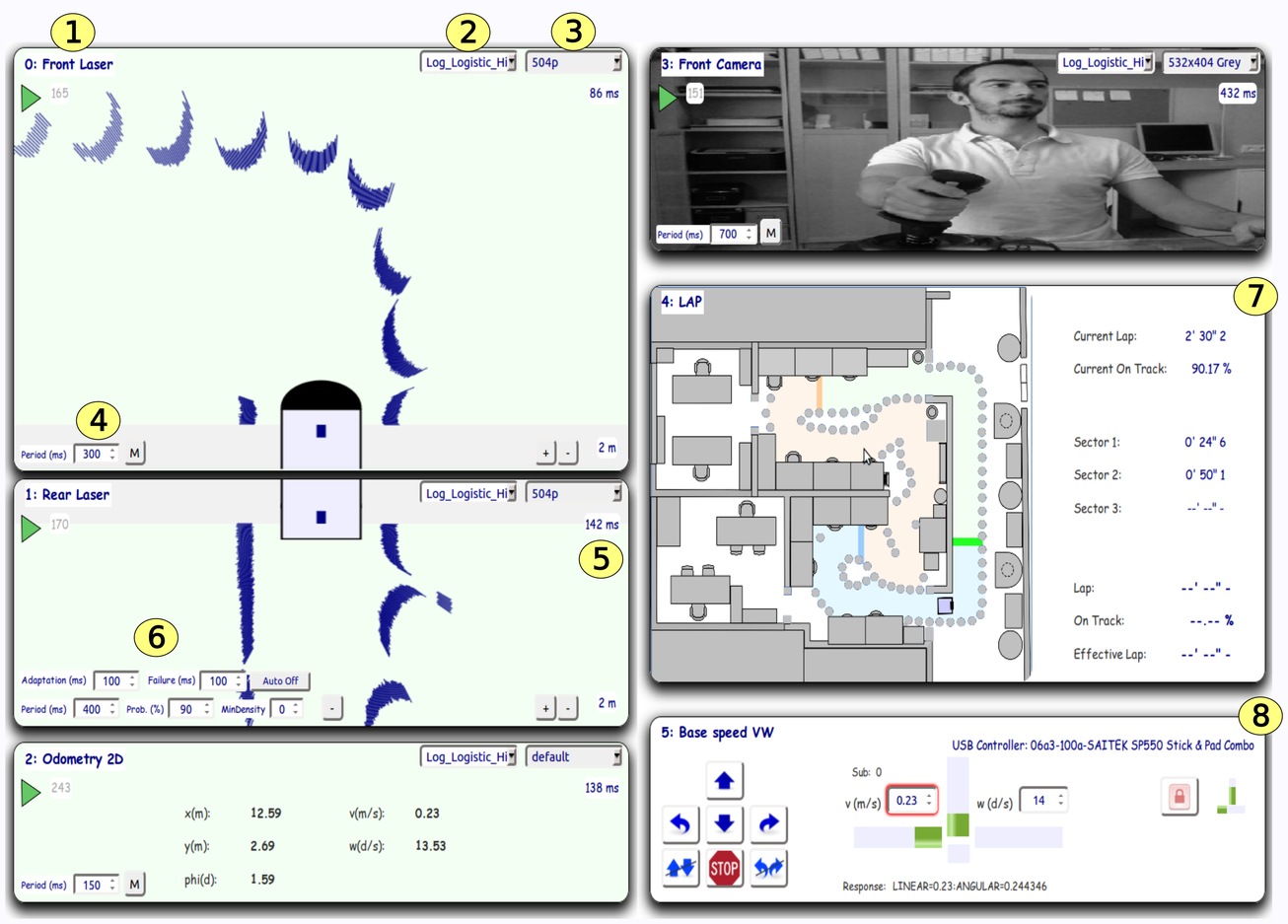


- Sets of sensors (*executives*) ordered from the best for solving the task to the least. Only one enabled.
- The regulator selects the most suitable executive and also activates/deactivates sensors transmissions depending on whether or not the soft real-time constraints are being met.

Fine Regulation: Variation of the amount of data

Low-Level

- Heuristic regulator algorithm: $max(\delta) \mid \pi_i(\delta) \geq \Pi i(\delta)$
- **$\pi_i(\delta)$** Probability of completing the transmission of a given amount of data **δ** from the i-th sensor before a given time τ_i. Estimated through a 3-parametrical log-logistic model of the transmission delays.

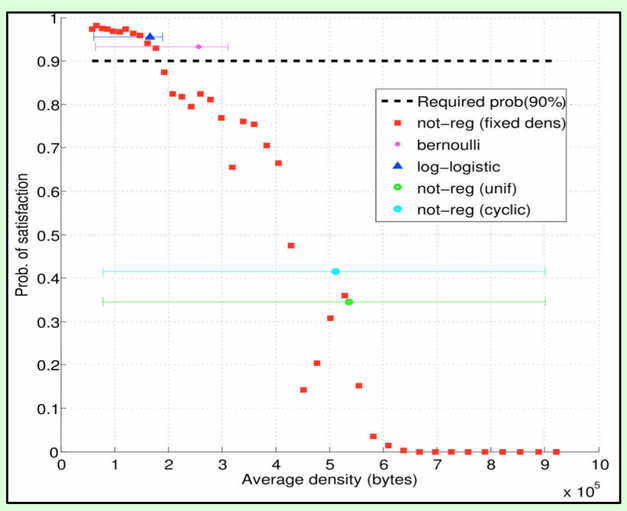


1. Sensor name
2. Delays modeler & fine regulator
3. Amount of transmitted data
4. Sensor refresh interval (req.)
5. Current refresh interval
6. All real-time requirements
7. Experiment information
8. Current motion command

EXPERIMENTAL RESULTS

A: Fine regulation algorithm only

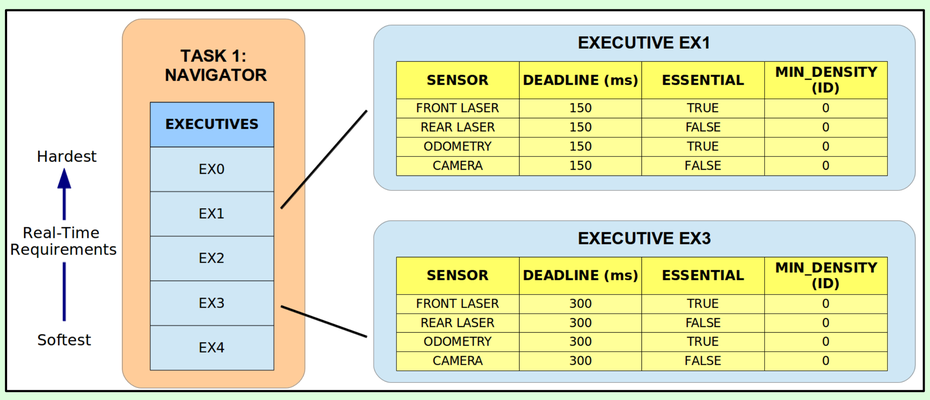
Webcam requested at different resolutions



Real-time requirements satisfied

B: Complete hiearchical controller

Simulated robot teleoperated along a track



λ : Laptime (s)
o : Fraction of λ within track limits
λeff= λ+10(1-o)λ (s) : Effective laptime

Average λ_{eff} *(after 50 experiments)*		Coarse regulation: YES	Coarse regulation: NO
Fine regulation	Log-logistic + heuristic	**55**	58.4
	Bernoulli + heuristic	66.9	69.1
	Fixed min density	-	57.5
	Fixed max density	-	114.7

- Best perfomance with { Coarse regulation; Fine regulation with log-logistic delay modeler + heuristic regulator
- Maximization of sensory information
- Real-time & quality control requirements guaranteed statistically

This work has been supported by the Junta de Andalucía regional government and the E.U. Regional Development Funds through the research project P08-TIC-04282.