POLITECNICO DI TORINO
Dipartimento di Automatica e Informatica

PhD in Computer and Control Engineering

XXXI cycle

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Autonomous Navigation for Mobile Robots in Complex and Crowded Environments

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TIM

1. Context and Objectives

The presence of robots in our lives is growing and, in near future, the numbers of robots acting in contact with people will significantly increase.

This work focuses on:

- Safe autonomous navigation, without compromising the human safety and avoiding collisions with obstacles
- Two scenarios: *(i)* a safe navigation for UAVs in urban environment, and *(ii)* an autonomous navigation for wheeled robots in crowded environment

2. Safe navigation for UAVs

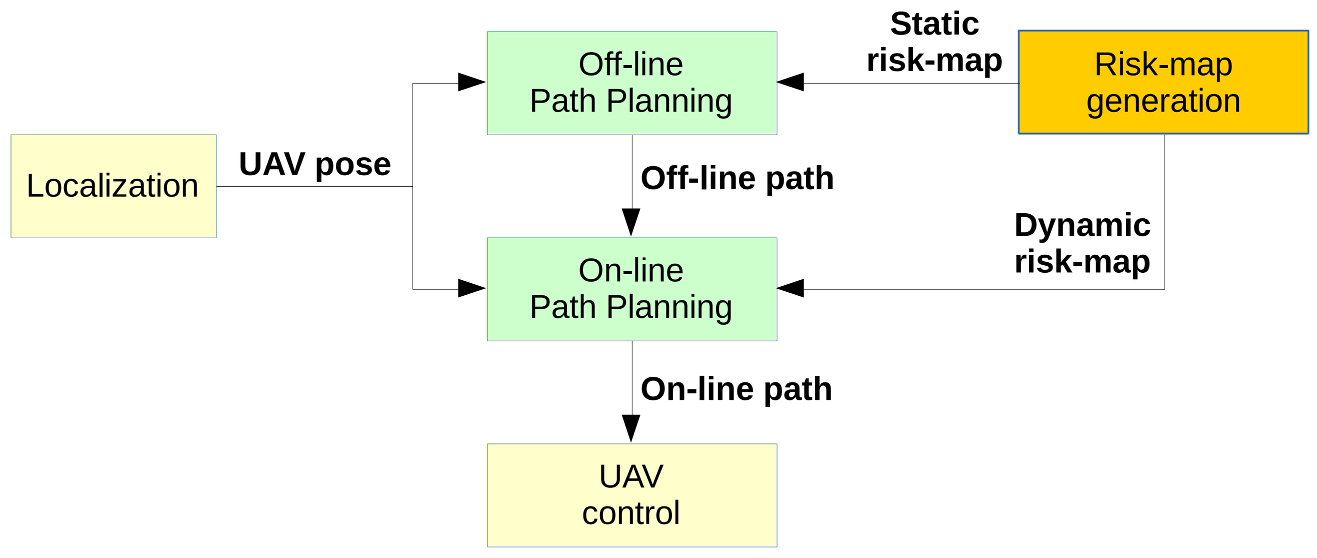

Fig. 1: Main architecture of the safe navigation for UAVs.

2.1 Ground risk map generation [1]

- The risk map quantifies the risk to people on ground
- The risk is defined as the hourly probability to have a casualty

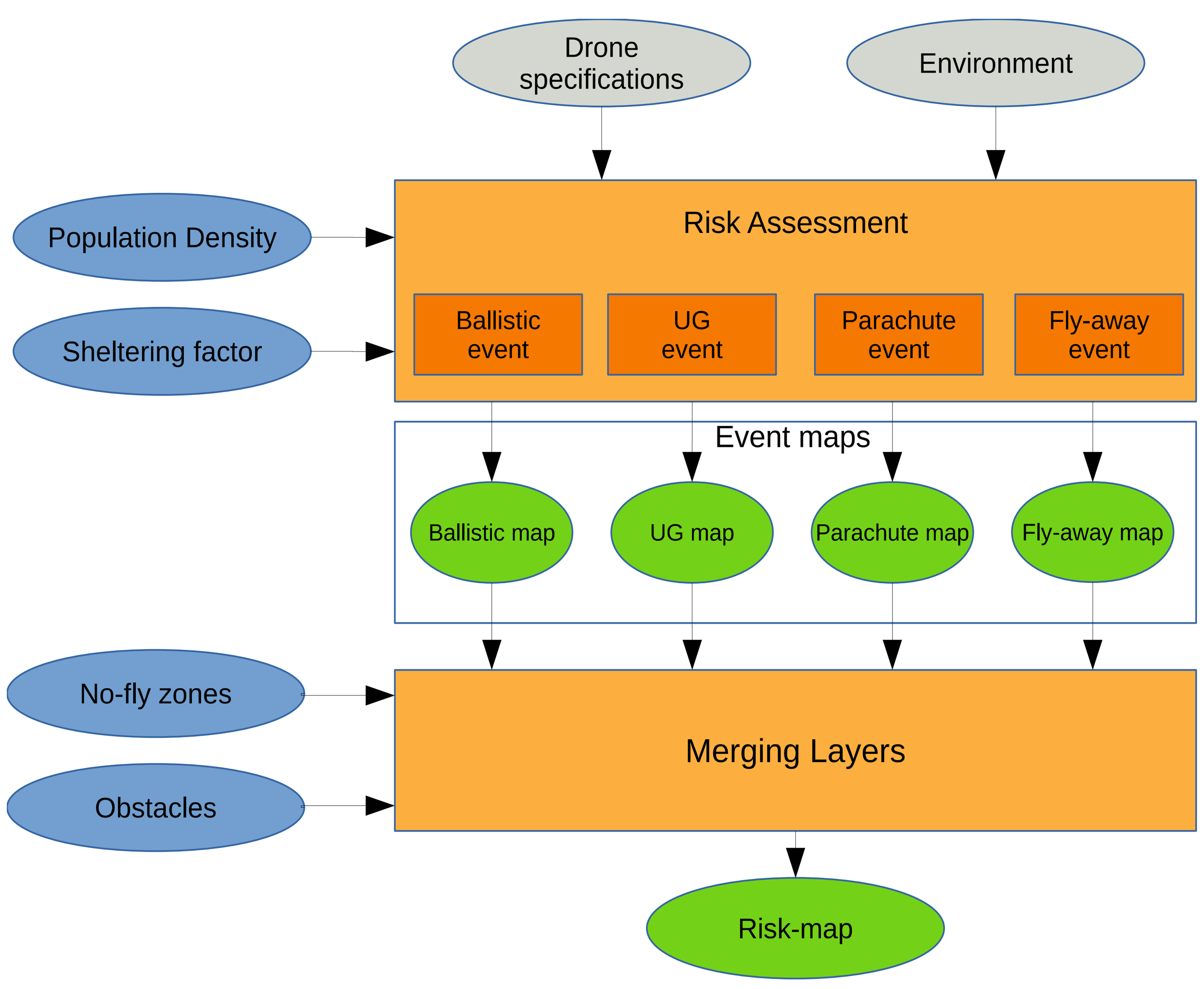

Fig. 2: The architecture of the generation of ground risk map.

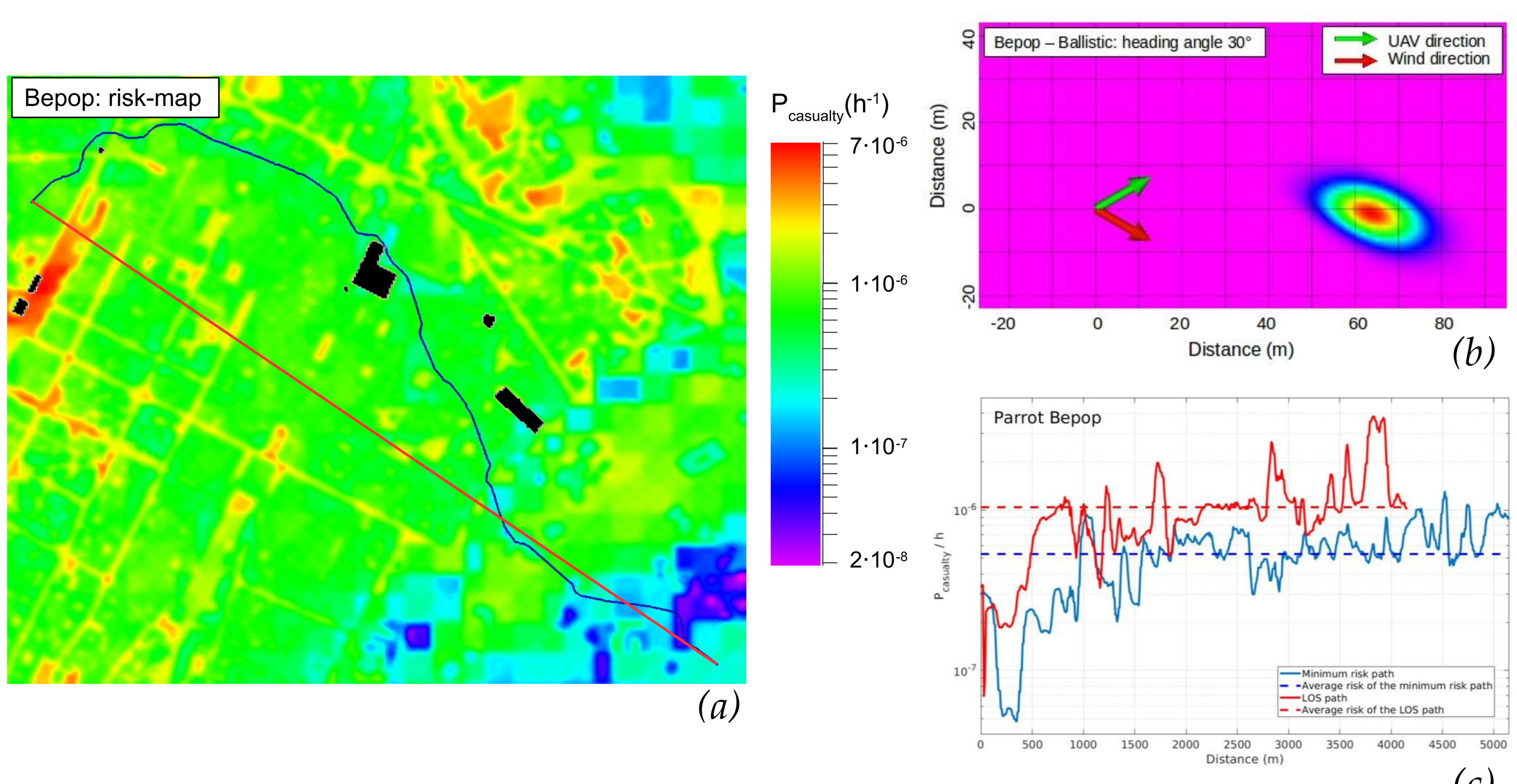

Fig. 3: In (a), the risk map of Turin with the minimum risk path computed with riskRRT^X. In (b), the impact area of a ballistic descent. In (c), the risk distribution of the computed paths.

2.2 Risk-aware path planning [2] seeks for a minimum risk path

- Offline path planning considers a static risk map. *Solutions: riskA*, riskRRT^X*
- Online path planning adapts the off-line path according to the dynamic risk map. *Solutions: Borderland, riskRRT^X*

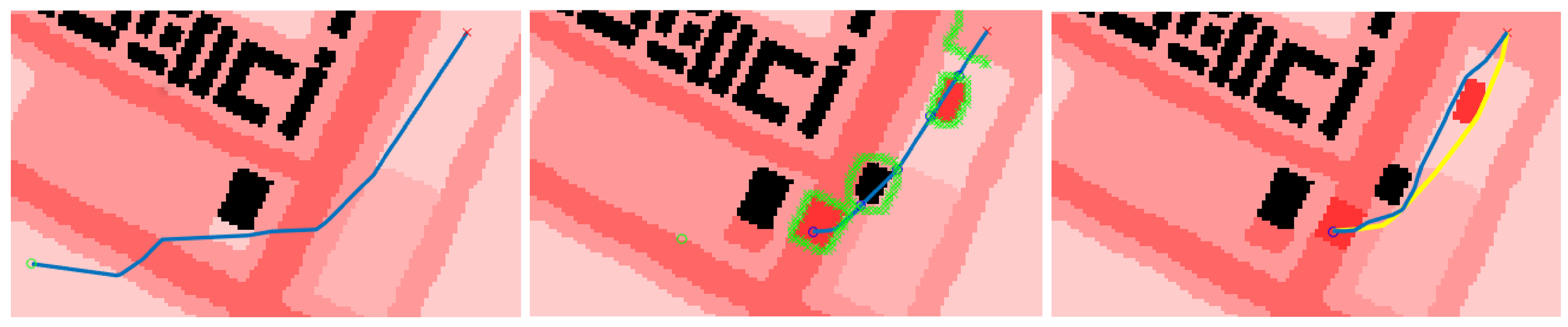

Fig. 4: Risk-aware path planning using riskA and Borderland [2].*

3. Navigation in crowded environments

3.1 Dynamic path planning with Informed-RRT* [3]

- It computes and maintains a valid path through people
- The planner continuously updates the path, according to the dynamic environment

3.2 Motion control with Particle Filter Model Predictive Equilibrium Point Control (PF-MPEPC) [4]

- It performs a safe and smooth navigation for wheeled robots
- It uses the Equilibrium Point approach to search for the optimal equilibrium point near the robot
- Particle filters in the prediction improve the safety

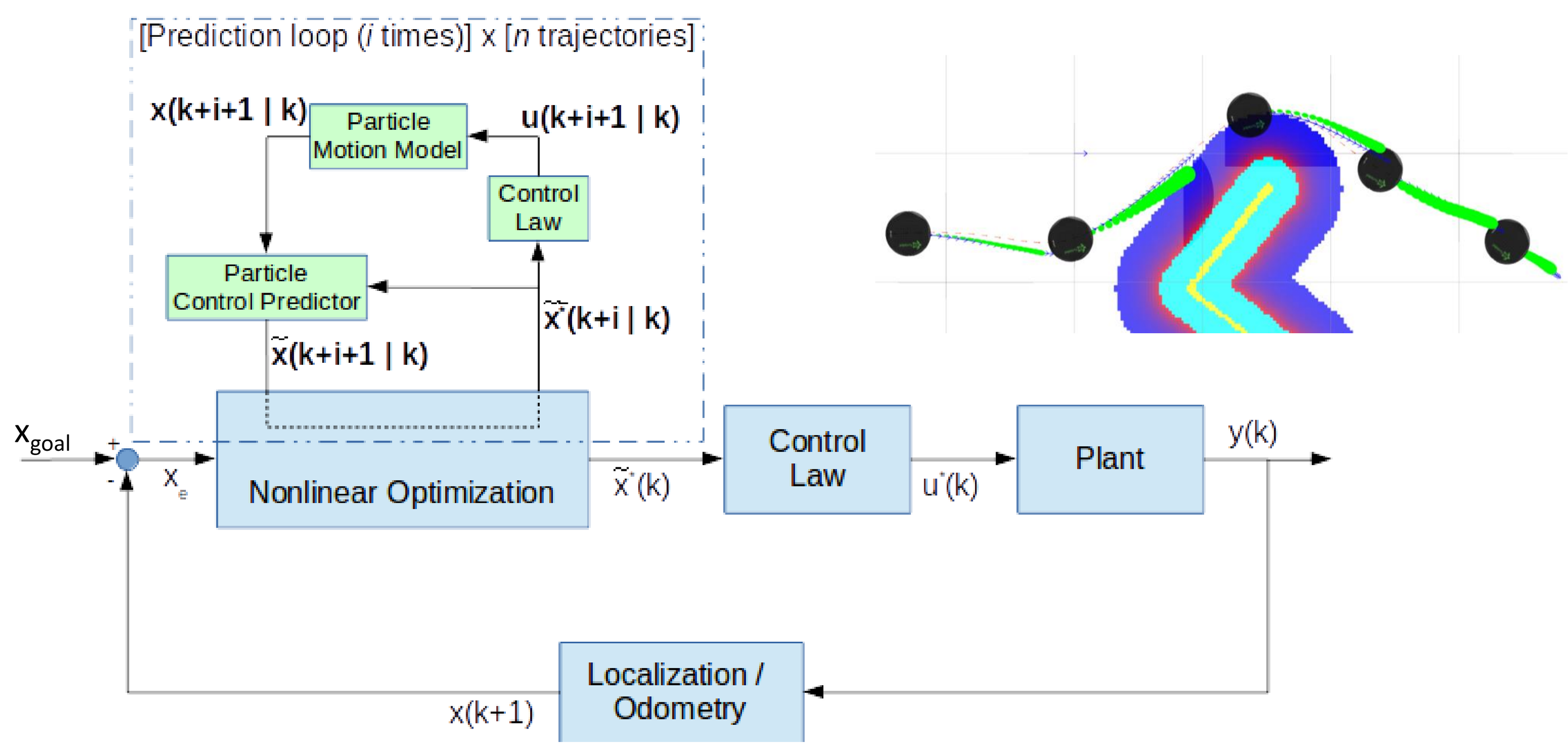

Fig. 5: Architecture of the PF-MPEPC approach.

3.3 Applications: Virgil, a robot in a museum; Robot Courier, a Cloud-based service robotic application in a workspace.

4. Conclusions

- Some methods for autonomous navigation in complex and crowded environments are proposed
- In both scenarios, robots perform a safe navigation without compromising the human safety and avoiding obstacles

5. References

[1] Primatesta, S.; Rizzo, A.; la Cour-Harbo, A. (2018) "Ground Risk Map for Unmanned Aircraft in Urban Environments". *(Submitted).*

[2] Primatesta, S.; Guglieri, G.; Rizzo, A. (2018) "A Risk-Aware Path Planning for UAVs in Urban Environments". In: *Journal of Intelligent and Robotic Systems.*

[3] Primatesta, S.; Russo, L. O.; Bona, B. (2016) "Dynamic Trajectory Planning for Mobile Robot Navigation in Crowded Environments". In: *ETFA 2016, International Conference on Emerging Technologies and Factory Automation.*

[4] Primatesta, S.; Bona, B. (2017) "Motion Control of Mobile Robots with Particle Filter Model Predictive Equilibrium Point Control". In: *ICARSC 2017, International Conference on Autonomous Robot Systems and Competitions.*

6. Acknowledgements

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