Target Detection and Tracking
A Guided Tour

Cyril Robin & Simon Lacroix

LAAS-CNRS

ECAI - MACOREX
August 18th, 2014

cyril.robin@laas.fr – simon.lacroix@laas.fr

A Messy Vocabulary

Example: "pursuit-evasion"

refers to:

[Parsons, 1978] **Search for a random** target in a known graph – find the minimal number of searcher;

[Vieira et al., 2009] Game against an **adversarial known evader** with multiple pursuers on a given map;

[Bhattacharya and Hutchinson, 2009] **Two players** pursuit-evasion game with **visibility constraints** in a polygonal environment (Nash Equilibrium);

[Karaman and Frazzoli, 2011] **Evading** from multiple known pursuers, **online resolution** with numerical "RRT*-like" approach;

[Kolling and Carpin, 2010] Multi-robot **search** of unknown targets **without map**;

inter alia.

A Messy Vocabulary

Other ambiguous words: coverage, search, surveillance, tracking...

Plus various vocabulary may refer to the same thing
e.g. tracking, pursuit-evasion, following,...

Why ?

- various contexts (industrial, civilian, military)
- various communities (sensor, maths, robotics, planning, game theory,...)

A Messy Vocabulary

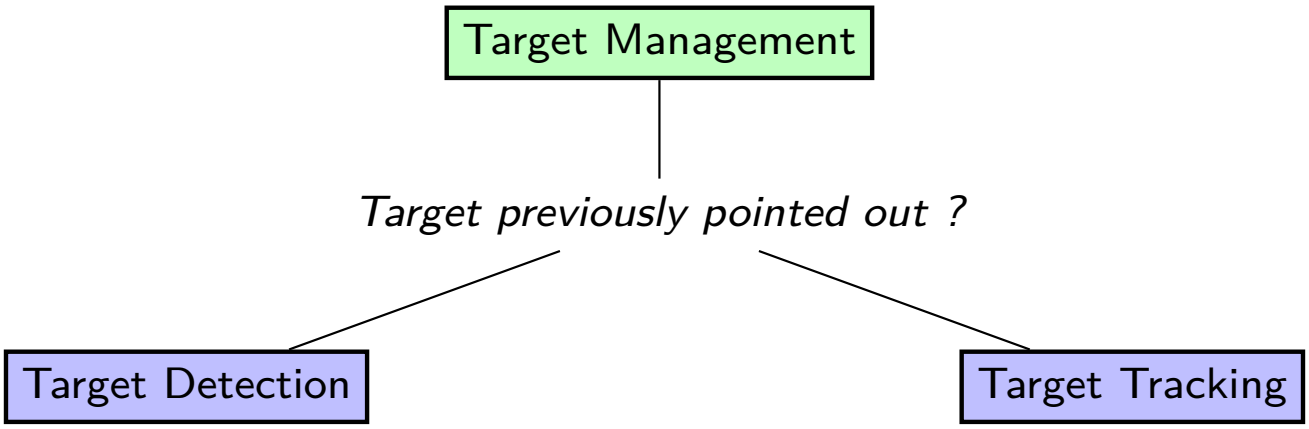
Other ambiguous words: coverage, search, surveillance, tracking...

Plus various vocabulary may refer to the same thing
e.g. tracking, pursuit-evasion, following,...

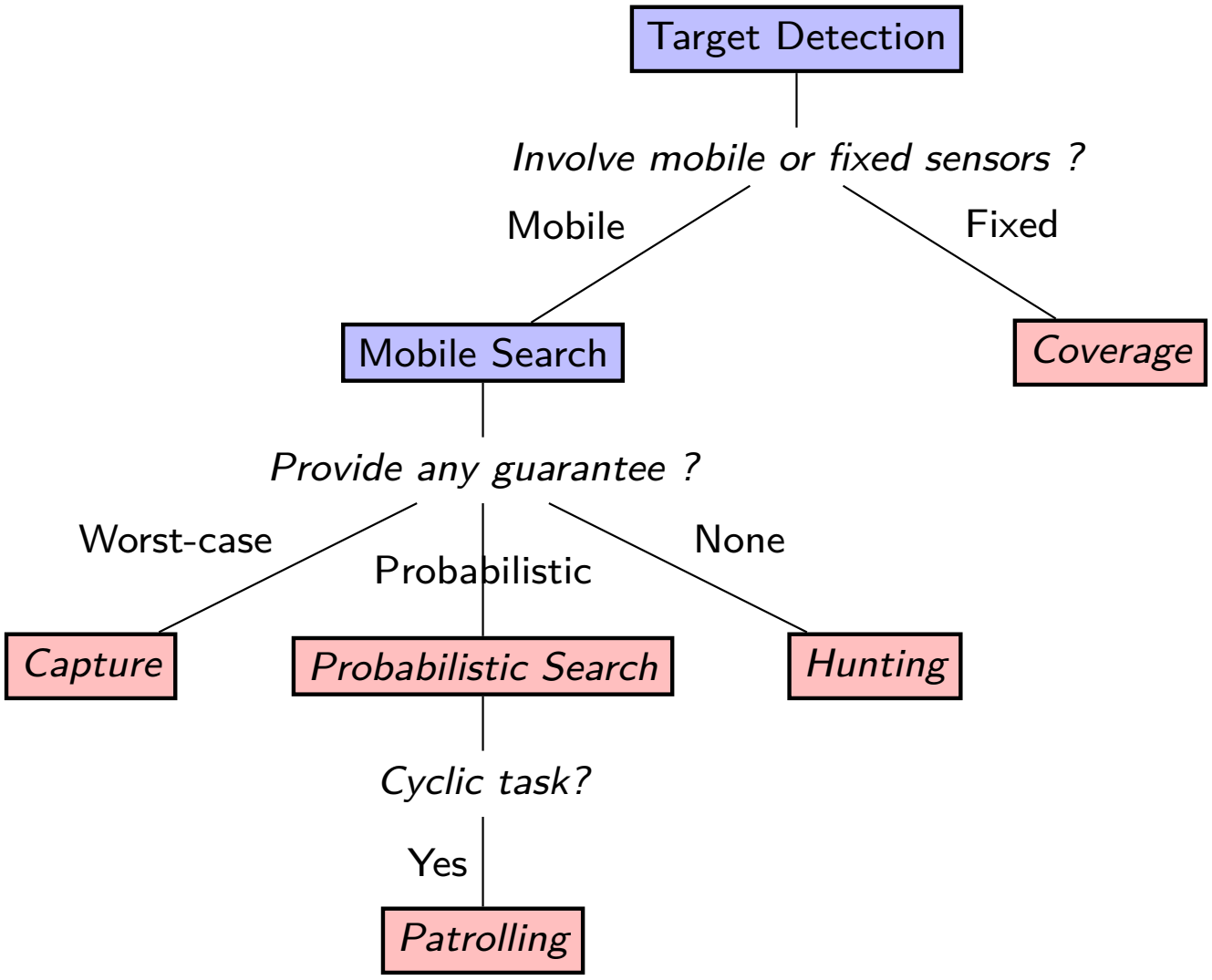
Why ?

- various contexts (industrial, civilian, military)
- various communities (sensor, maths, robotics, planning, game theory,...)

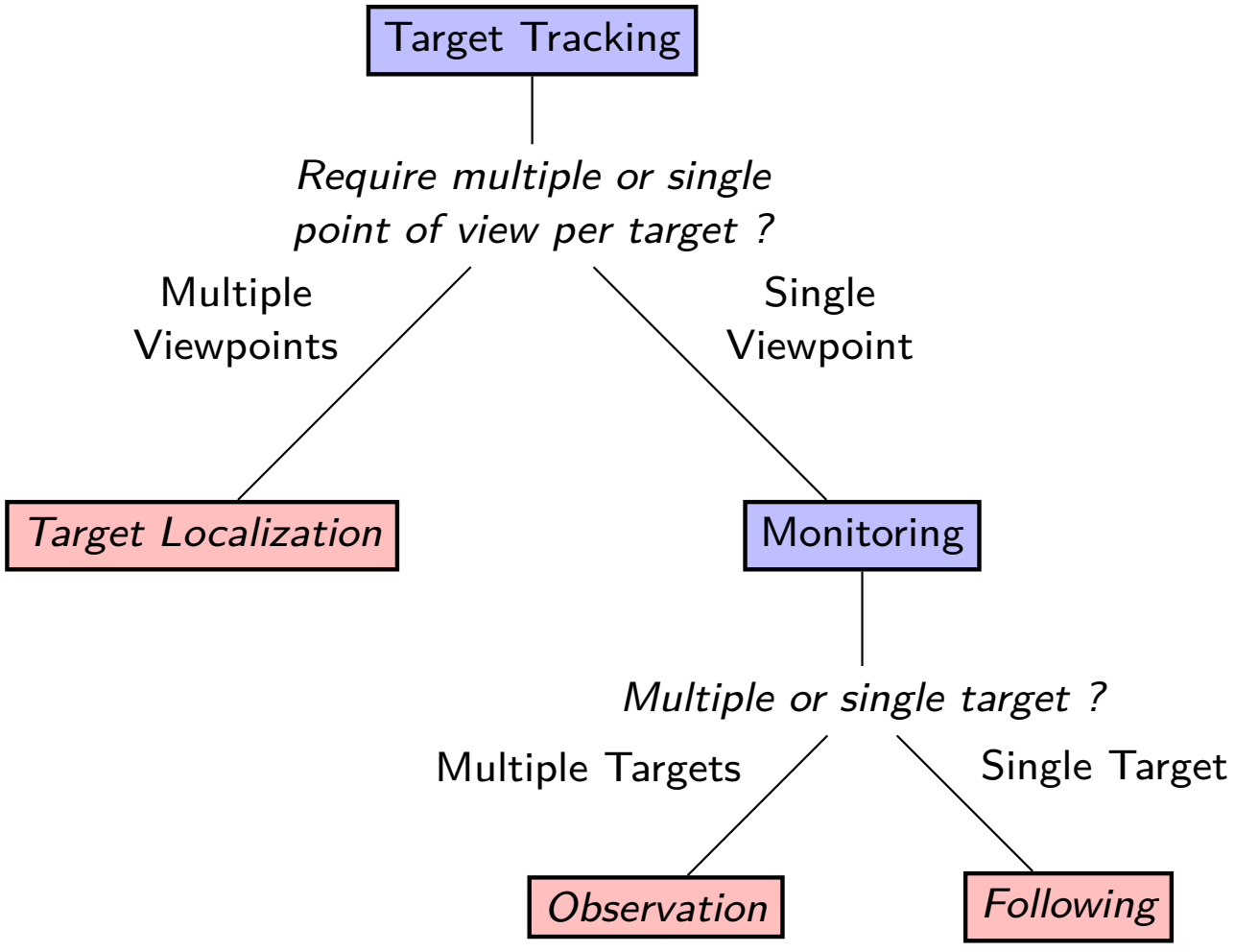
A Unifying Task-Oriented Taxonomy



Taxonomy: Target Detection



Taxonomy: Target Tracking



Taxonomy $\rightarrow$ Survey

The taxonomy helps to gather and analyse the related papers

Lead to a vast survey (over 100 papers reviewed),

from which we synthesize :

- the common models
- the common approaches
- the main kinds of results

Common models : the World

- Beyond 2D $\rightarrow$ 2.5D, 3D, multilayer
- Continuous and Discrete worlds
  Meaningful Topology & computational issues
- The (discrete) Space-Time manifold
- Environmental Constraints

Common models : the agents

- Motion: node-based (cost estimation) $\rightarrow$ pattern-based
- Sensors: node- or distance-based $\rightarrow$ full geometric model
- Communication (full connectivity and beyond)
- Expected behaviour

Common approaches

- Theory / Practice
- Centralized $\rightarrow$ Decentralized
- Cooperation (none, explicit, implicit)
- Handling Uncertainties and dynamism
- Planning / Optimization

Results and Validation Process

Theoretical and Practical Results

Validation Process

- *ad-hoc* simulations are the norm
- lack realism
- lack of benchmark
- lack of "culture of statistics"
- recent improvements

Actual validation is costly, but we can have synergies.

Synthetic Conclusion

Research on the topic are

- Going towards richer models
- With decentralized cooperative systems
- The main flaw is the validation process
- We don't exploit synergies enough
  - $\rightarrow$ neither between communities nor between research teams

Thank you for your attention today.

References

Bhattacharya, S. and Hutchinson, S. (2009).
On the Existence of Nash Equilibrium for a Two-player Pursuit–Evasion Game with Visibility Constraints.
The International Journal of Robotics Research, 29(7):831–839.

Karaman, S. and Frazzoli, E. (2011).
Incremental sampling-based algorithms for a class of pursuit-evasion games.
Algorithmic Foundations of Robotics IX.

Kolling, A. and Carpin, S. (2010).
Multi-robot pursuit-evasion without maps.
In *ICRA'10*.

Parsons, T. (1978).
Pursuit-evasion in a graph.
Theory and applications of graphs.

Vieira, M., Govindan, R., and Sukhatme, G. (2009).
Scalable and practical pursuit-evasion with networked robots.
Intelligent Service Robotics.