Tutorial: Constraint Programming for Robotics

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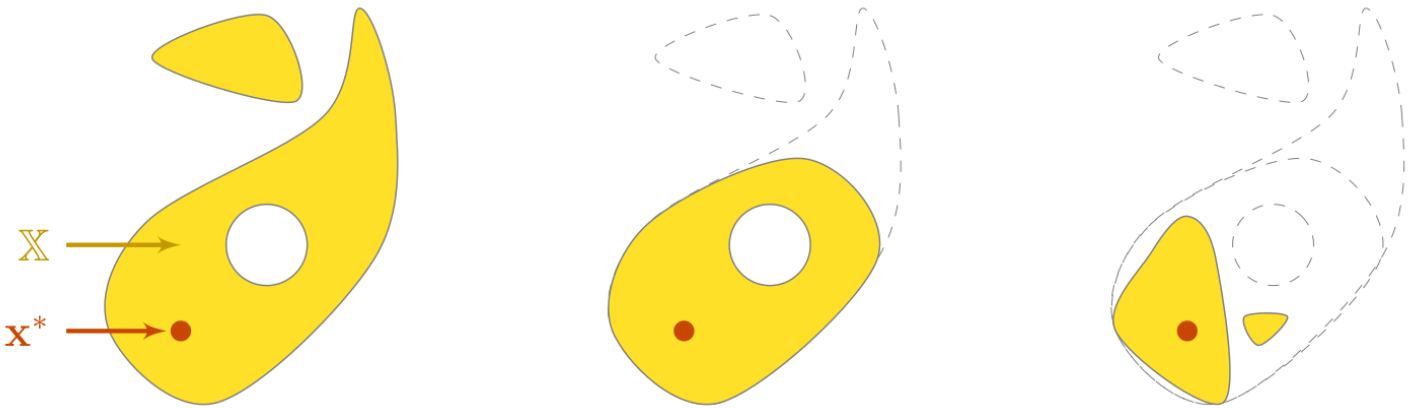
Constraint Programming

- Goal: state estimation in mobile robotics
- Given:
  - a set of constraints/rules (coming from state equations)
  - a (possibly infinitely large) initial estimation of the solution
- Idea:
  - let a solver perform the estimation by adhering to all constraints
  - inconsistent parts of the initial estimation are removed from the solution set

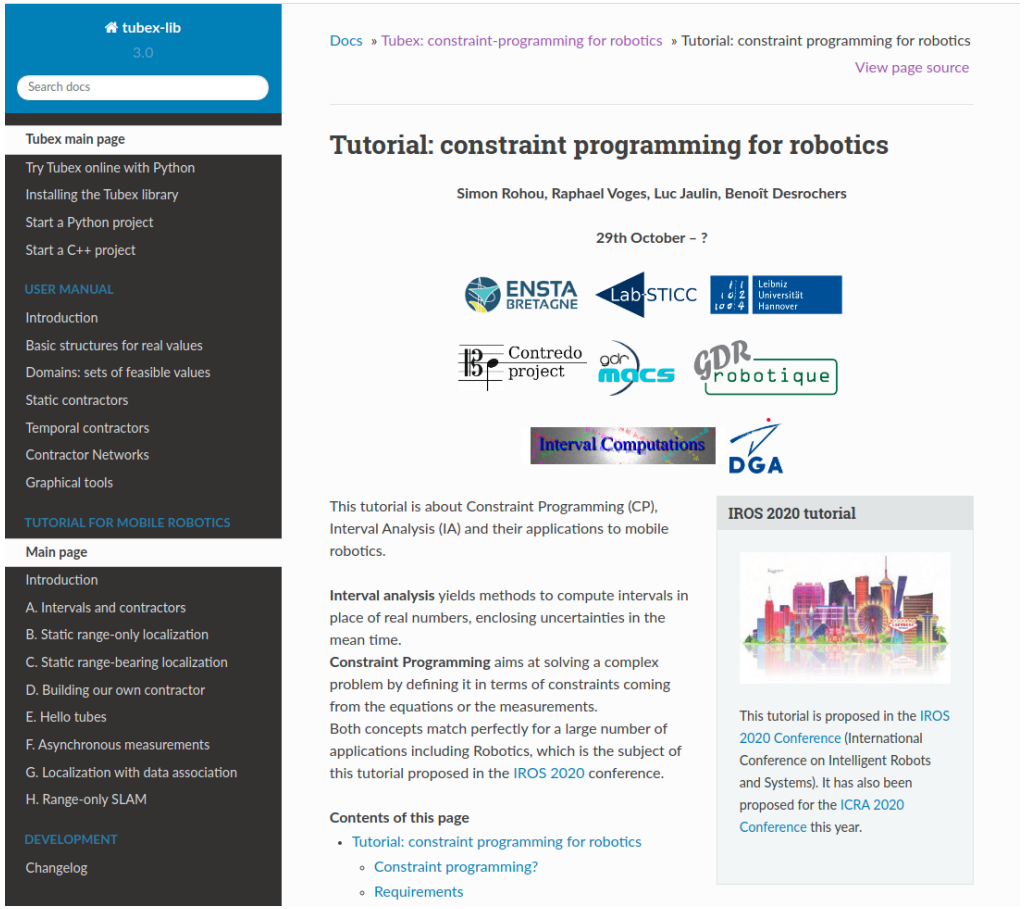


Organization

- The tutorial stands on the Tubex library (`https://github.com/SimonRohou/tubex-lib`)
- Requirements: basic knowledge of Python or C++ (the exercises are available in both languages)
- Four weeks of exercises starting from October 26th
  - Week 0 (installation) must be completed previously
- By completing all exercises, it is possible to obtain a Diploma (equivalent to 40 hours of lessons)
- Interactive meeting sessions every Tuesday afternoon at 2PM (UTC) starting from October 27th
- Slack channel for easy communication (will be announced on the website)

Organization

- All information and exercises are available on the tutorial website
- `http://simon-rohou.fr/research/tubex-lib/doc/tutorial`

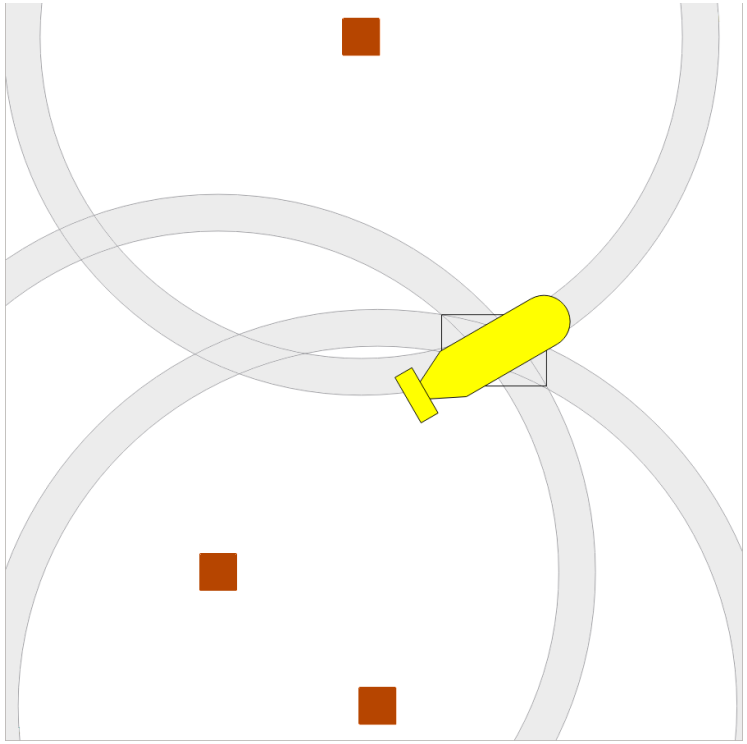


Tutorial Content: Week 0

- Introduction to the concepts of Constraint Programming and Interval Analysis
- Installation of the Tubex library
- Run some *Hello World!* program to ensure that everything works

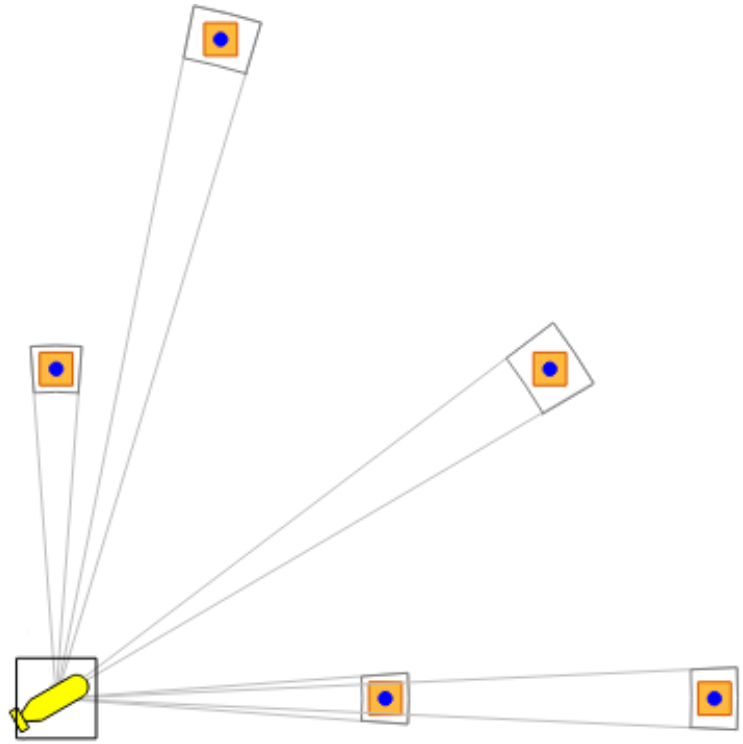
Tutorial Content: Week 1

- **Lesson A: Getting started with intervals and contractors**
- Serves as an introduction to intervals, constraints and networks of contractors
- **Lesson B: Static range-only localization**
- State estimation of a static robot between some landmarks
- Initial assumption: the robot does not move
- Measurements (constraints): range-only data from the landmarks



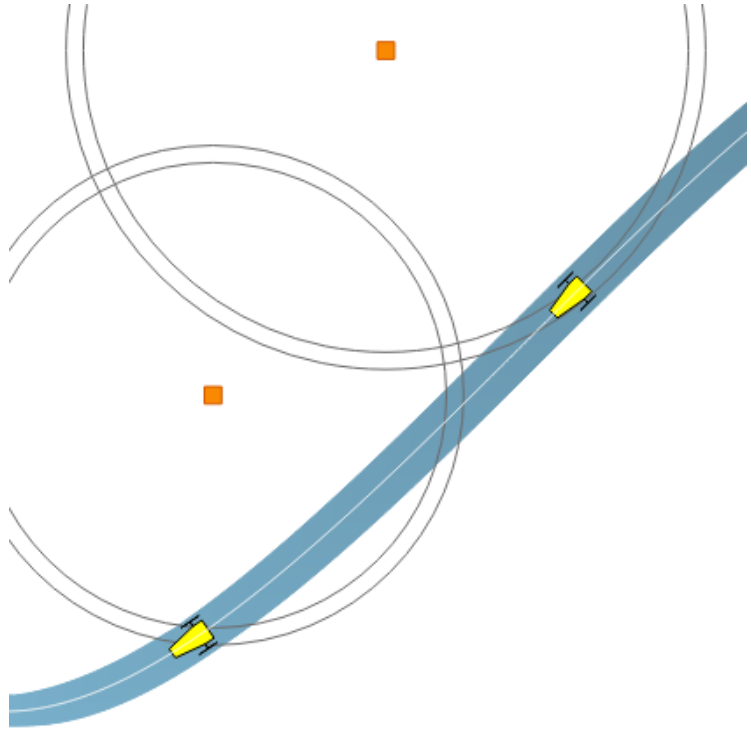
Tutorial Content: Week 2

- **Lesson C: Static range-and-bearing localization**
- Measurements (constraints): both range and bearing data
- A decomposition of the problem becomes necessary
- **Lesson D: Building our own contractor**
- Indistinguishable landmarks: association problem
- Develop our own contractor to solve this problem



Tutorial Content: Week 3

- **Lesson E: Hello tubes**
- Dealing with uncertainties on trajectories
- **Lesson F: Localization with asynchronous measurements**
- Range-only localization (cf. Lesson B) in a dynamical context with asynchronous measurements



Tutorial Content: Week 4

- **Lesson G: Dynamic localization with data association**
- Set-membership state estimation by solving data association
- Extension of the problem from Lesson D to a dynamical context
- **Lesson H: Range-only SLAM**
- Simultaneous Localization and Mapping (SLAM)
- Application of all previous concepts of constraints and interval analysis
- (optional) Online SLAM