XXVII FIG CONGRESS
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Volunteering for the future – Geospatial excellence for a better living

New automatic method of free stationing by drone

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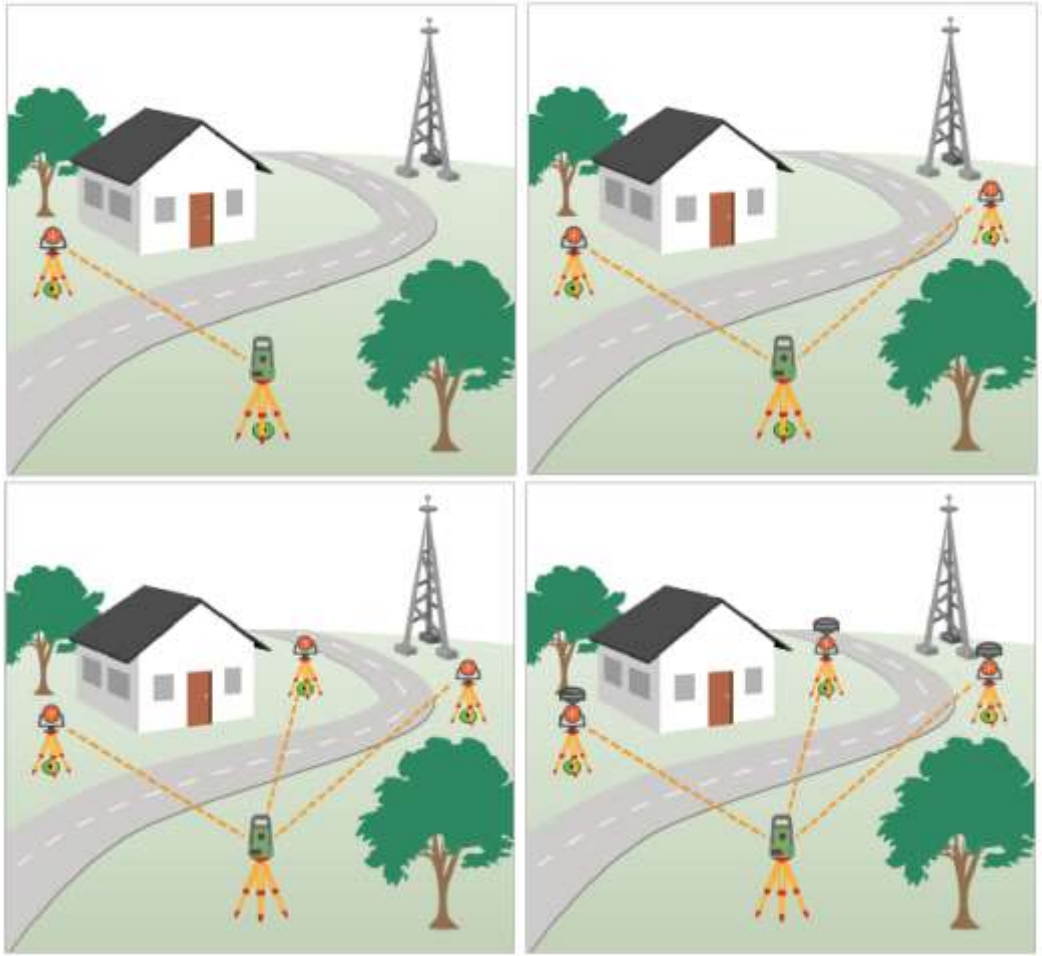
Setting up a total station : state of the art

- 4 main solutions
  1. Orientation on benchmark
  2. Multiple orientations on benchmark
  3. Free station
  4. Free station coupled with a GNSS sensor

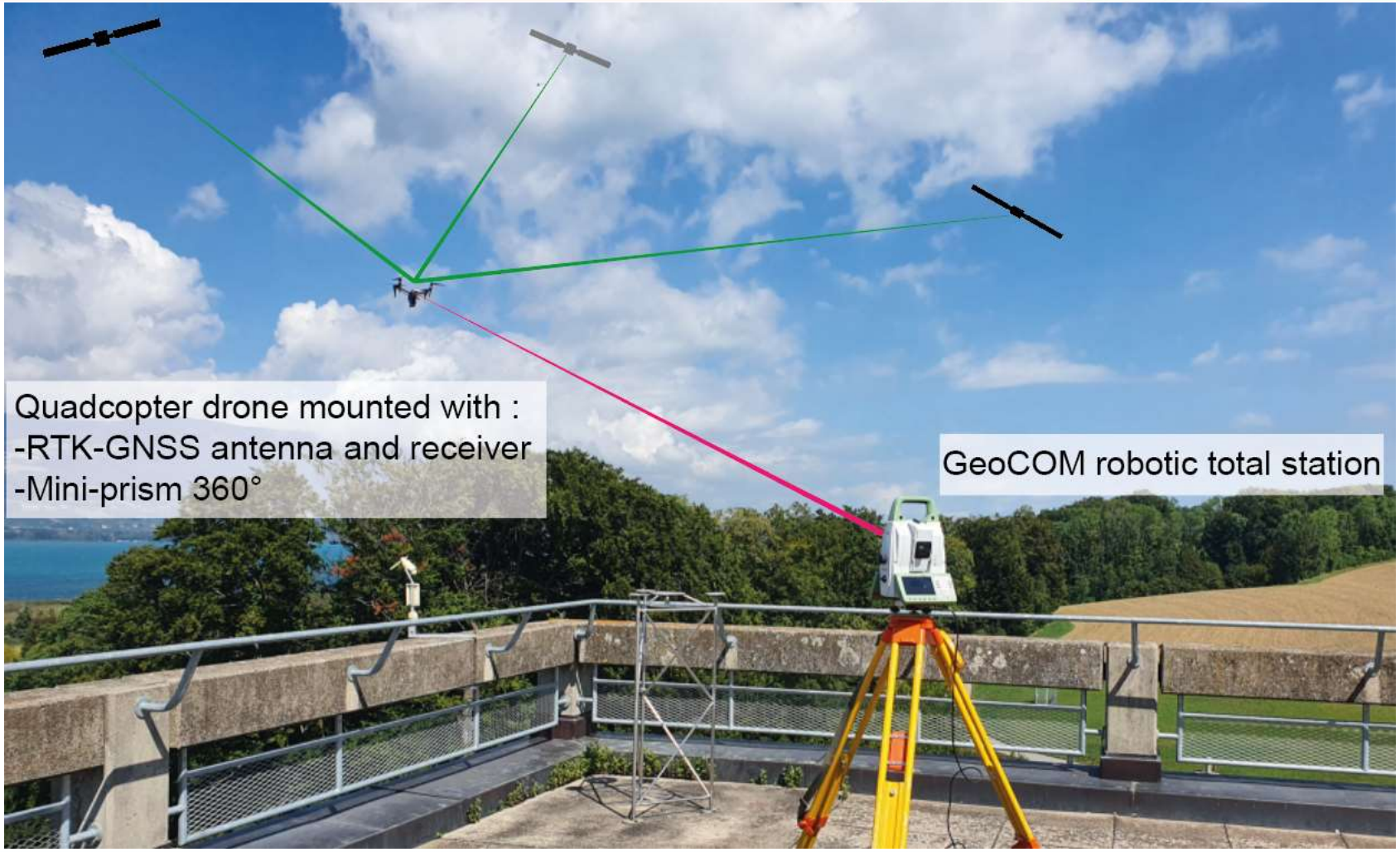
- Limitations :
  - Rely on benchmarks or a GNSS receiver on the ground
  - Direct line of sight
  - Obstruction masks



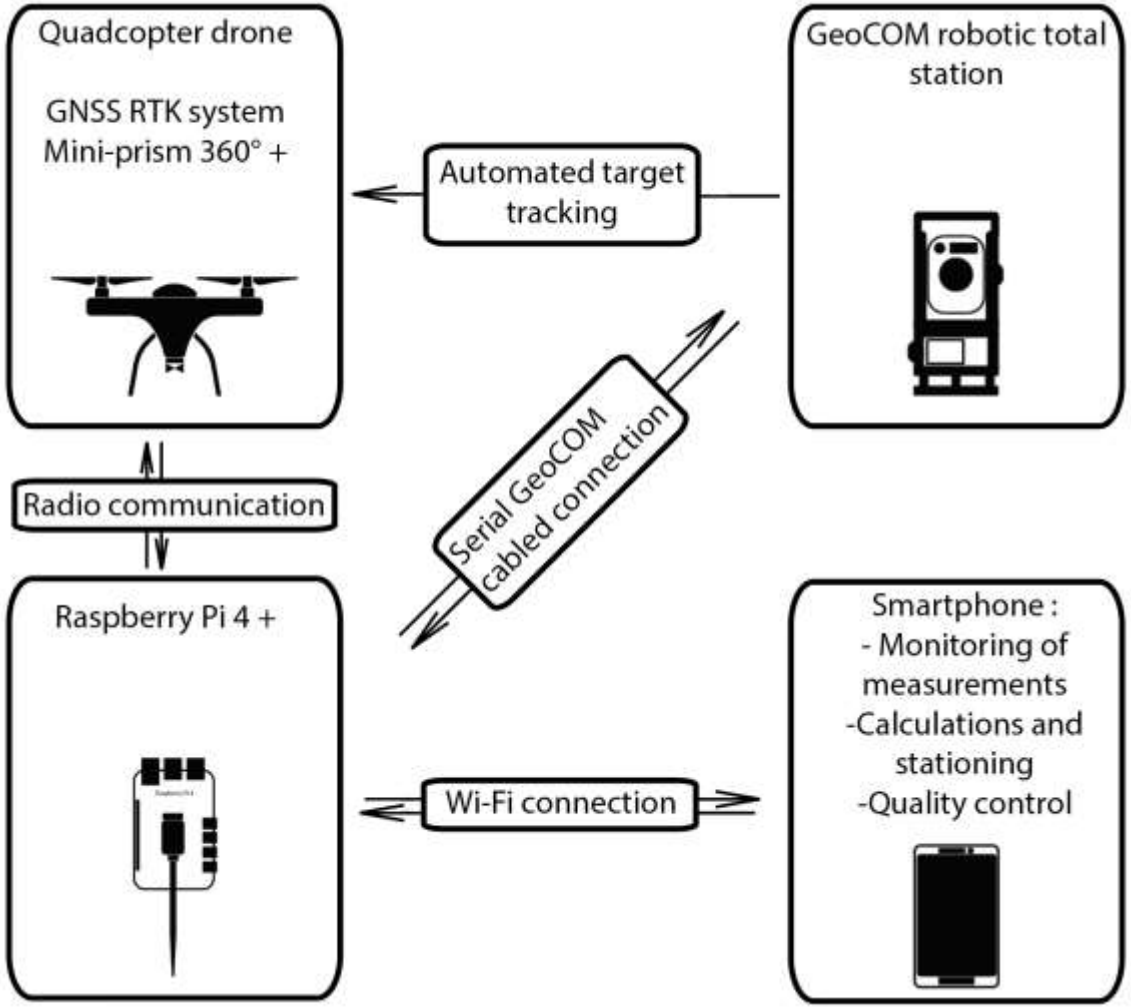
HEXAGON - Leica Gesosystems AG

Concept

- Objectives :
  1. Low-cost
  2. Easy to implement
  3. Modular system
  4. Open-source
  5. Robust implementation



Hardware & Software



Acquisition methods

- Measured data :
  - GNSS : CH1903+ projected coordinates
  - Total station : Raw observations (angles and distances)

- Stop and go :
  - Filtering of points groups when the drone is considered static
  - Optimal in low visibility areas

- Dynamic :
  - Complete 3D trajectory of the drone
  - Ideal in high visibility areas without benchmarks

Alignment of the two trajectories (global and local coordinates)

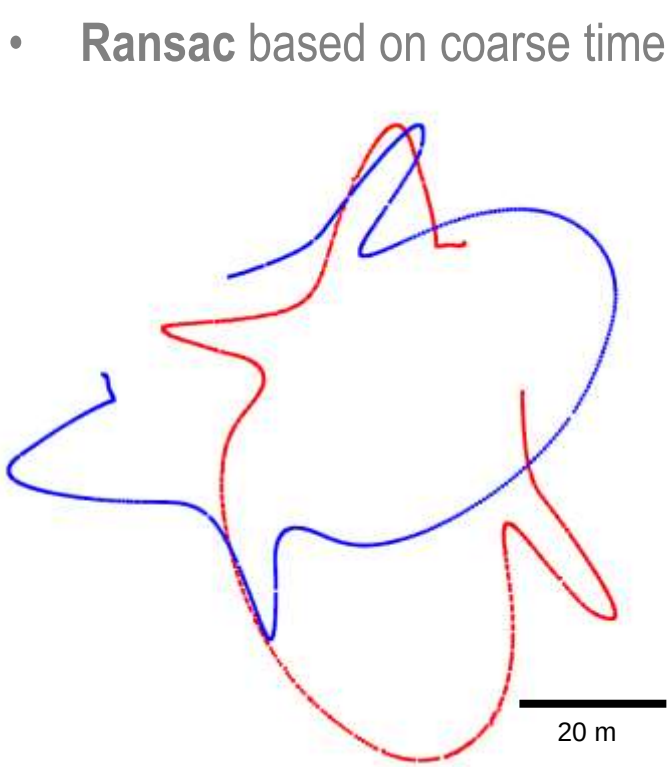
- **Problematic** : No precise correspondence between points (from GNSS and total station)

  ⟹ Impossible to calculate an accurate transformation with Helmert or even RANSAC

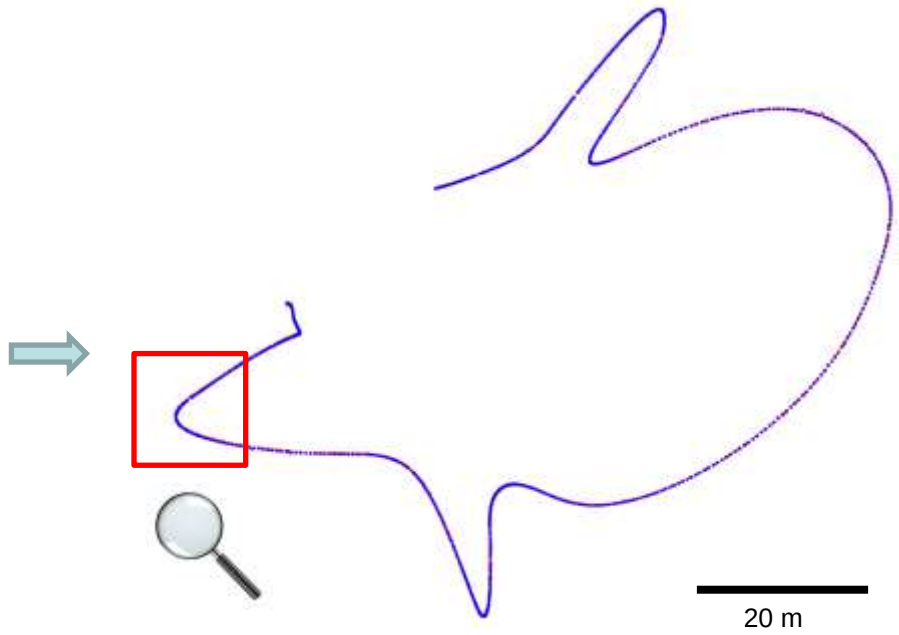
- **Reasons** :
  - Timestamp of Total station
  - Non-constant data transmission time
- **Solutions** :
  - Use a **stop & go acquisition** (mean on static points, no longer need a precise time-based correspondence)
  - Use of a first coarse alignement with RANSAC based on coarse time correspondence followed by a precise alignment non-based on time

Alignment of the two trajectories (global and local coordinates)

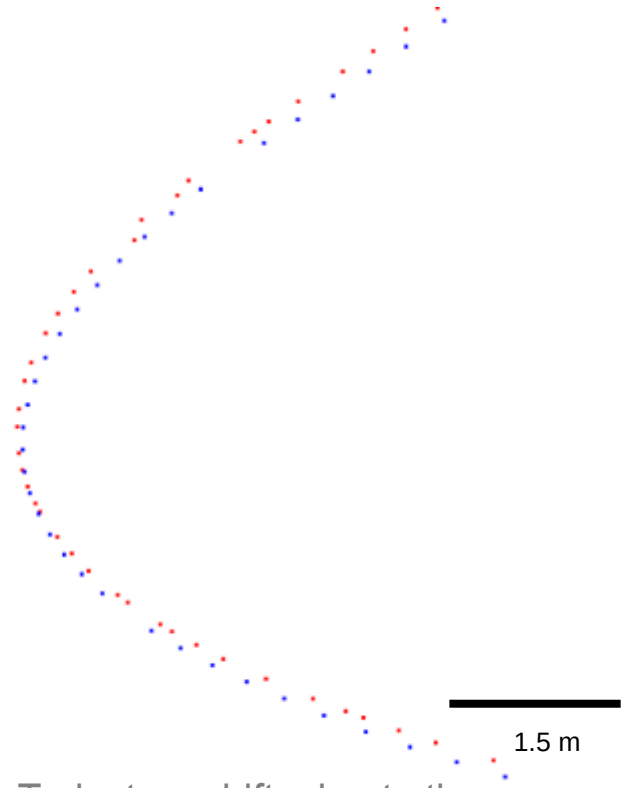
- **Ransac** based on coarse time correspondence



Raw trajectories



Trajectories after RANSAC alignment



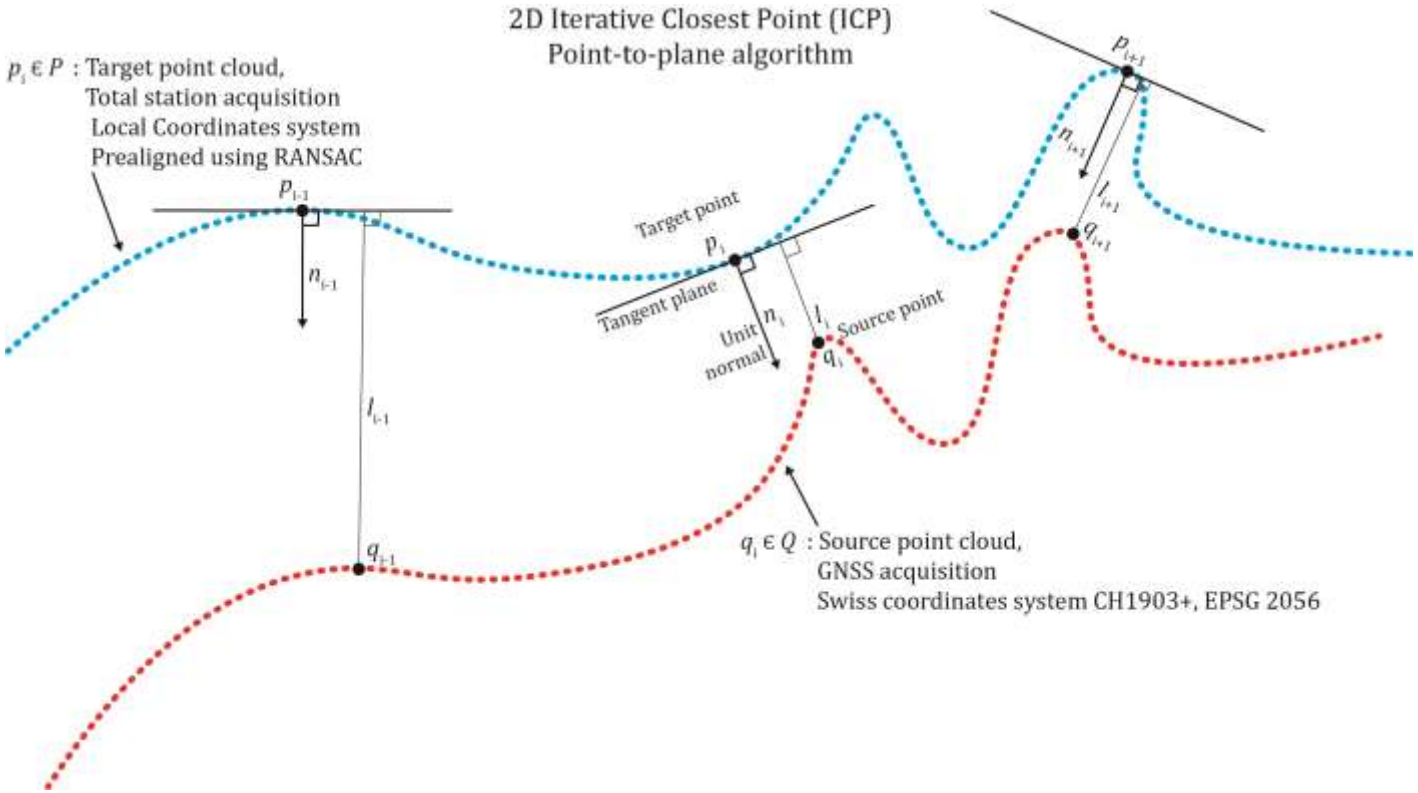
Trajectory shifts due to the use of time for alignment

Point-to-Plane 2D ICP algorithm

Why Point-to-Plane?

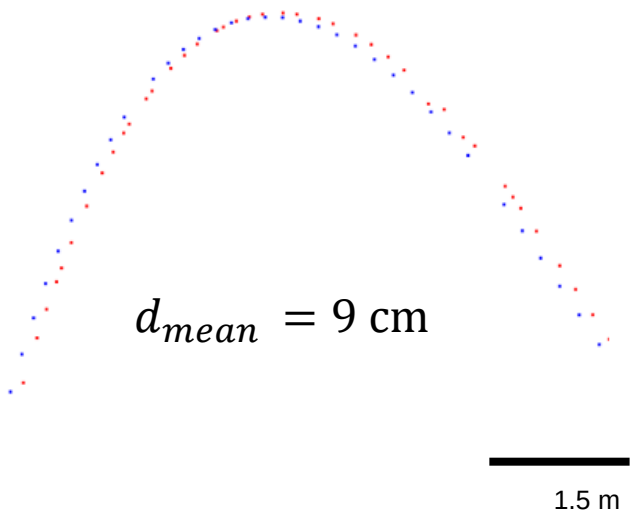
Using a classical ICP (point to point) in the **presence of a systematic error** on the time measurement (non-random offset), the alignment result would also be **impacted by this systematic error.**

Not with Point-to-Plane in our configuration.

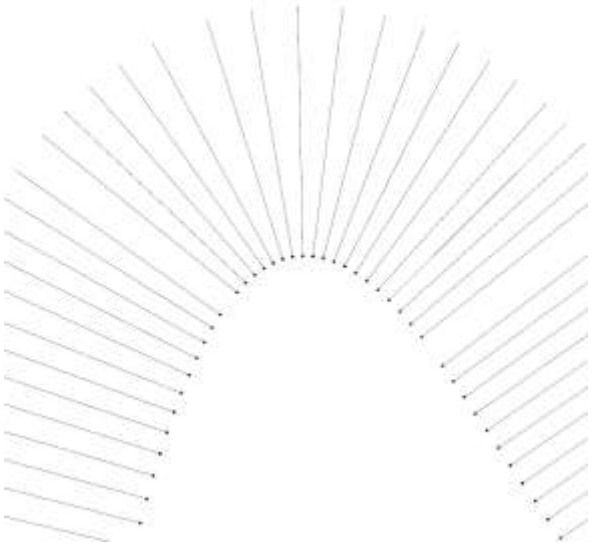


Principle of Point-to-Plane ICP

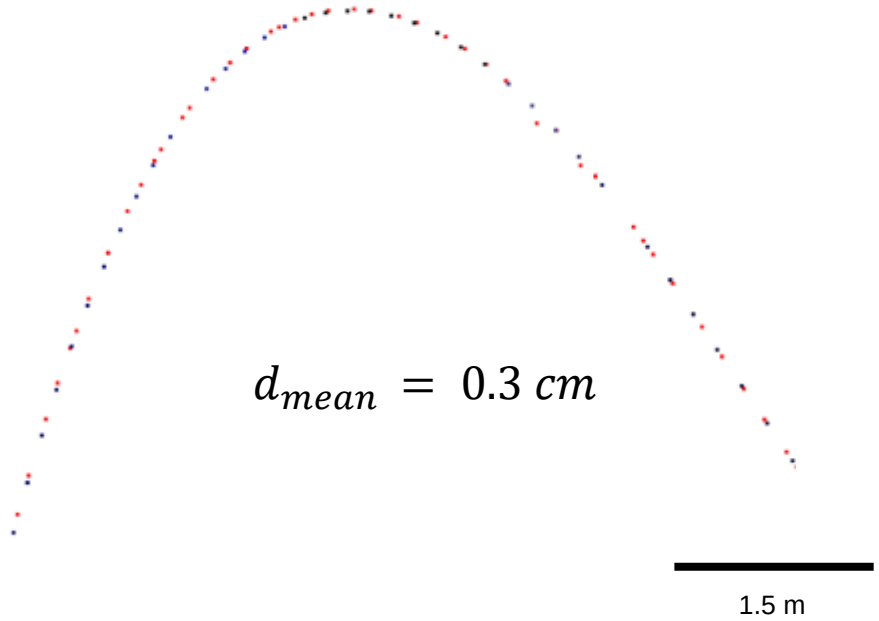
Point-to-Plane 2D ICP computation



Trajectory shifts due to the use of time for alignment



Calculation of normals for Point-to-Plane ICP alignment

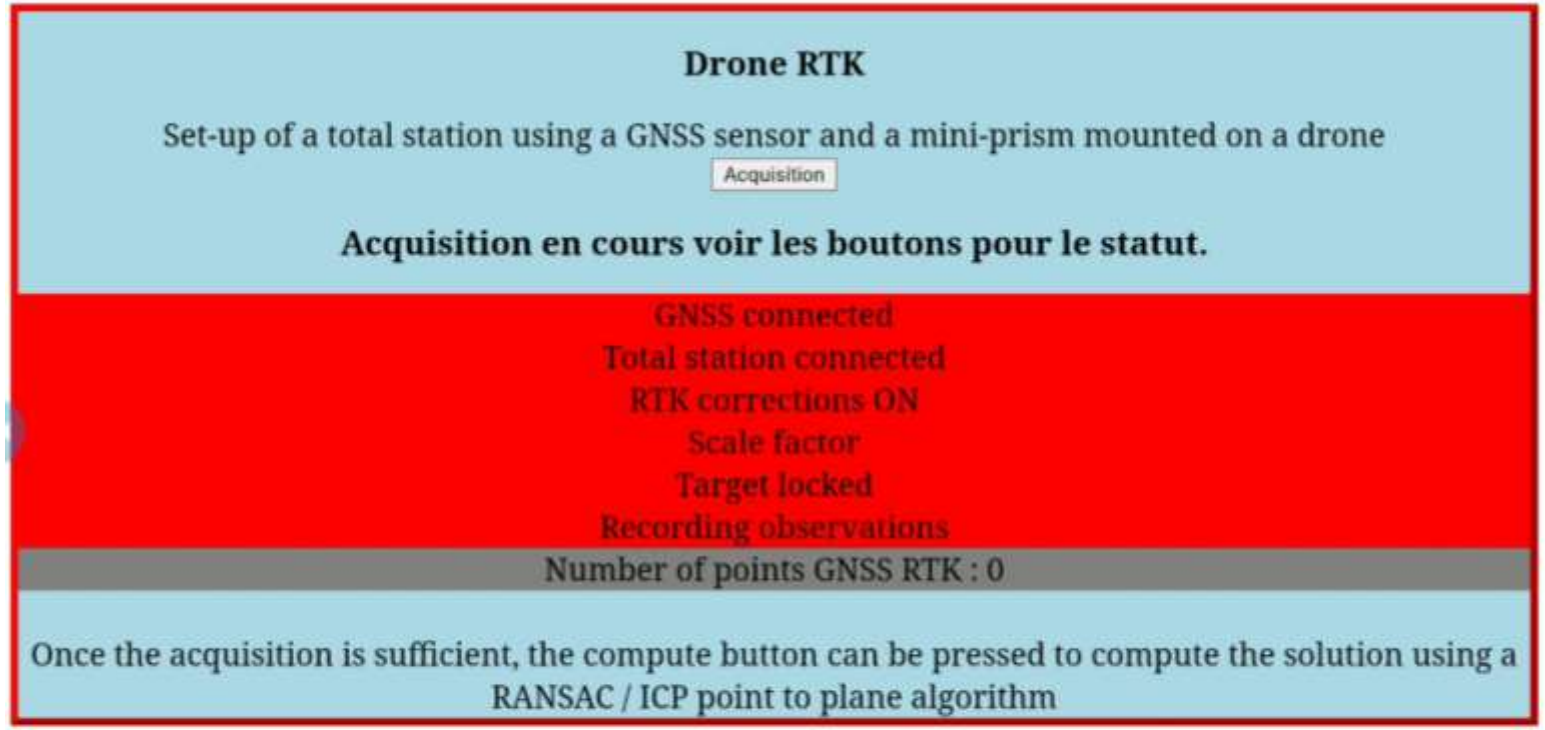


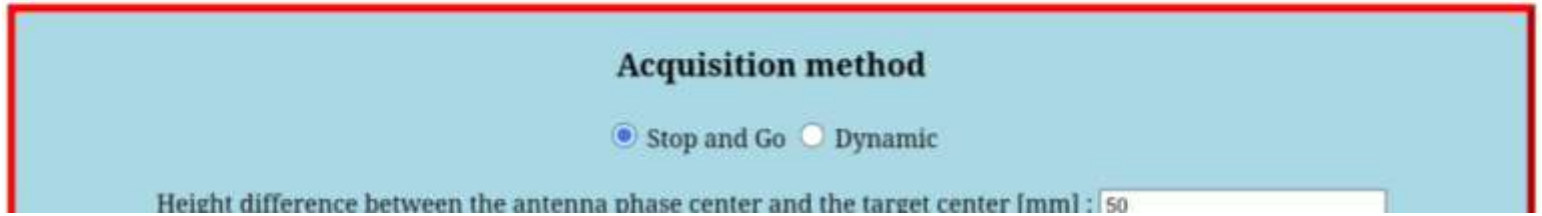
Resulting precise alignment after the Point-to-Plane ICP

Application

- Connection to the Raspberry Pi Wifi
- Access to Local HTML page

- Control of the acquisition
- Computation of the RANSAC / ICP algorithm
- Automatic set up of the total station
- Quality control of the results





Results

- Centimetric 3D RMSE
- Orientation : < 0.01 m at 100 m

- Quality of the positioning and orientation directly related to the GNSS accuracy

- Validation of the accuracy has been carried out in a network with millimetric precision as reference

- Tests in difficult environnments were carried out and gave satisfying results of reliability

	Drone RTK static stationing	Drone RTK dynamic stationing	Free station on Benchmarks	Free station based on GNSS points
σ 2D [m]	--	--	0.003	0.008
σ H [m]	--	--	0.004	0.013
RMSE ICP 2D [m]	0.006	0.029	--	--
RMSE ICP 1D [m]	0.019	0.004	--	--
σ ω [rad]	0.00004	0.00006	0.00003	0.00004
Δ 2D Station [m]	0.006	0.011	0.002	0.007
Δ 3D Station [m]	0.013	0.018	0.010	0.015
Δ 2D Control [m]	0.006	0.010	0.003	0.018
Δ 3D Control [m]	0.018	0.013	0.012	0.031

Perspectives and future developments

- Long range orientation
- Trimble robotic total stations compatibility
- Online publication of the solution on GitHub
- Miniaturization of the system

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