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VisNav Exercise 01: Solution

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Exercise 1: Odometry

- State-Space: 3D rigid body pose
  - $\mathbf{x} = (x, y, z, \Phi, \Theta, \Psi) \in \mathbb{R}^6$

  - $\mathbf{x} = (x, y, z, \omega_x, \omega_y, \omega_z) \in \mathbb{R}^6$

  - $\mathbf{x} = (x, y, z, q_x, q_y, q_z, q_w) \in \mathbb{R}^7$
    with $\|(q_x, q_y, q_z, q_w)\| = 1$

Exercise 1: Odometry

- Odometry Vector: Measurements

$$\mathbf{u} = (v_x, v_y, z, \Phi, \Theta, \Psi) \in \mathbb{R}^6$$

v_x, v_y horizontal velocity

z relative height

Φ roll

Θ pitch

Ψ yaw (already integrated up)

Exercise 1: Odometry

- "measured" horizontal velocity v_x, v_y

  - projected onto horizontal plane

  - computed from

    - IMU

    - motion-model

    - optical flow on bottom camera

Exercise 1: Odometry

- "measured" relative height z

  - projected onto vertical axis

  - raw ultrasound measurements

Exercise 1: Odometry

- "measured" orientation (Φ , Θ , Ψ)

  - Φ , Θ (roll, pitch): no drift

    (thanks to gravity)

  - Ψ (yaw): drifts over time

Integrated gyroscope measurements

Exercise 1: Odometry

- Odometry model $\mathbf{x}_t = f(\mathbf{x}_{t-1}, \mathbf{u}_t) :$

$$\mathbf{x}_t = f(\mathbf{x}_{t-1}, \mathbf{u}_t) :$$

$$x_t = x_{t-1} + \delta_t(v_{x,t} \cos \Psi_t - v_{y,t} \sin \Psi_t)$$

$$y_t = y_{t-1} + \delta_t(v_{x,t} \sin \Psi_t + v_{y,t} \cos \Psi_t)$$

$$z_t = z_{\mathrm{obs},t}$$

$$\Phi_t = \Phi_{\mathrm{obs},t}$$

$$\Theta_t = \Theta_{\mathrm{obs},t}$$

$$\Psi_t = \Psi_{\mathrm{obs},t}$$

with:
$$\mathbf{u} = (v_x, v_y, z_{\mathrm{obs}}, \Phi_{\mathrm{obs}}, \Theta_{\mathrm{obs}}, \Psi_{\mathrm{obs}})$$
$$\mathbf{x} = (x, y, z, \Phi, \Theta, \Psi)$$

Exercise 2: Implementation

- Topics:
  - **/cmd_vel:** Sent control commands
    - linear x, y: desired roll / pitch angle
    - linear z: desired vertical speed
    - angluar z: desired yaw rotational speed
  - **/ardrone/navdata:** Sensor measurements
    - rotX, rotY, rotZ: roll, pitch, yaw (degree)
    - vx, vy: horizontal velocities (mm / sec)
    - altd: altitude (mm)
  - **/ardrone/image_raw:** Camera image
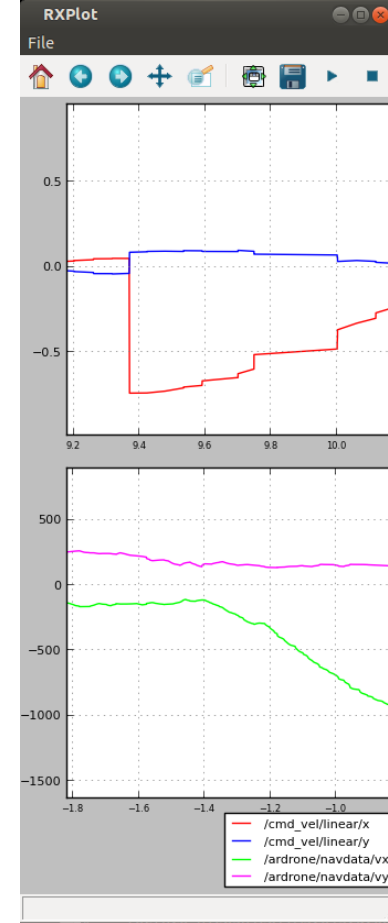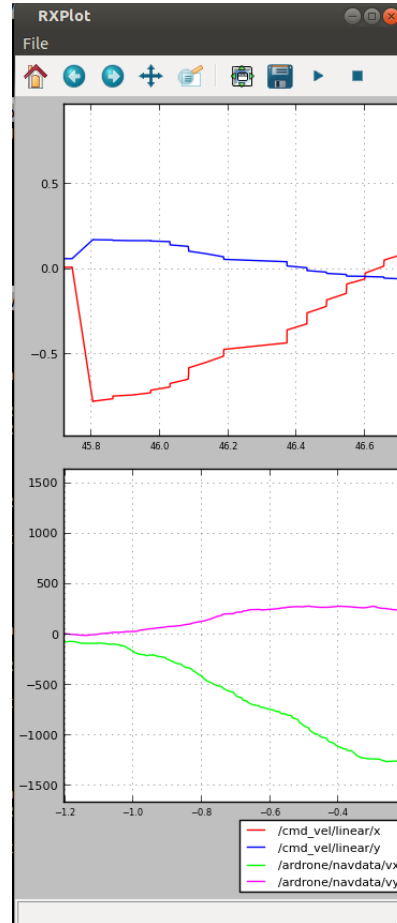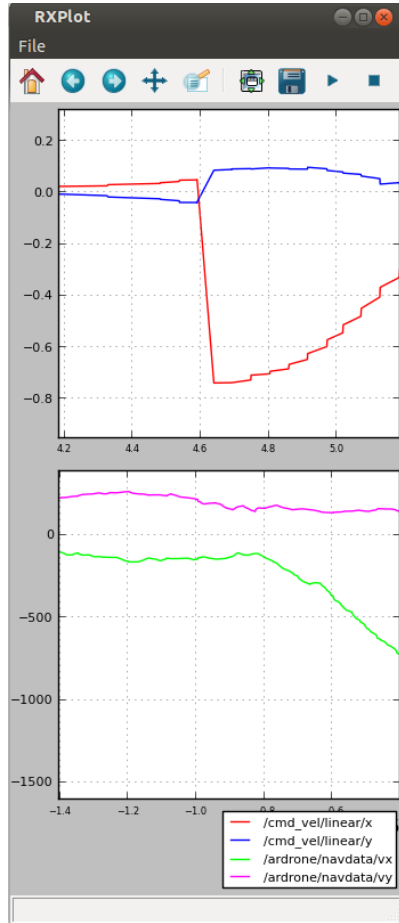 - **/ardrone/camera_info:** Camera calibration

Exercise 2: Implementation

>> rxplot -p 20 /cmd_vel/linear/x:y /ardrone/navdata/vx:vy
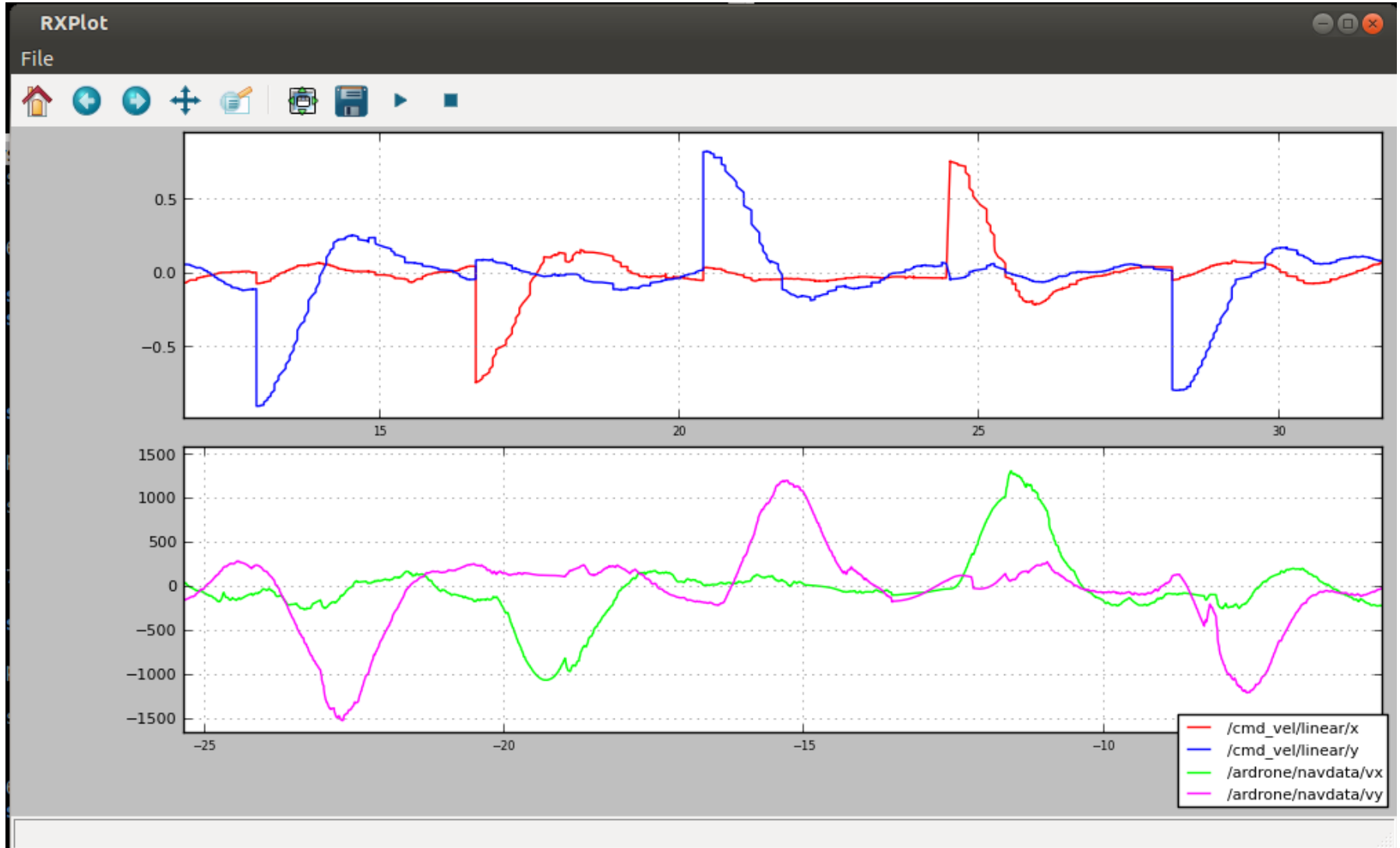
Exercise 2: Implementation

>> rxplot -p 1 /cmd_vel/linear/x:y /ardrone/navdata/vx:vy

Delay: 100ms - 200ms