Activities in Active Debris Removal (ADR)

CleanSpace One Project

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Swiss Space Center launched SwissCube, the first Swiss student satellite, in September 2009
- CubeSat family (10 x 10 x 10 cm³, 1 kg)
- SwissCube is on 720-km SSO orbit, still operational

After the launch, started research to develop technologies for Orbital Debris Removal of Non-Cooperative Debris (under a program called “Clean-mE”)
- Low level funding

CONCLUSION: research and development most efficient when targeted to a concrete application
=> Start of CleanSpace One project
The objectives of the CleanSpace One project are to:

1. Increase awareness, responsibility in regard to orbital debris and educate young people;

2. Demonstrate technologies related to Orbital Debris Removal;

3. De-orbit a known and politically acceptable debris.
CleanSpace One NanoSat

- **CleanSpace One NanoSat**
  - Remove 1 debris (> 10 cm, < 1m)
  - Based on a CubeSat 3U-6U platform as preliminary assumption
  - Preliminary (Phase 0) design done using CDF
  - VEGA or PSLV, launch ~ 2016-17

- Critical technologies provided by partner institutions (open to international cooperation). Satellite platform designed by students.

- Operations performed by students in partnership with larger and professional institutions
Technical Challenges for CleanSpace One

- In orbit maneuvering and Rendezvous
  - Development of highly efficient propulsion system and attitude control system for a nano-satellite to minimize amount of fuel that need to be carried. Key factor is how close can a launch vehicle deliver our flight system to the target.

- Target identification & tracking
  - Employ passive (Vision Based System) instruments to identify object and characterize its state (position and rotations)
  - Perform in phase manoeuvring, with high level of autonomy

- Grappling, safe, versatile, adaptative and reliable

- Controlled de-orbiting maneuver
Micro-propulsion system

• Propulsion needs to remove SwissCube:
  - Orbit altitude matching ~ 120 m/s (from 500 km)
  - RAAN changes ~ 50 m/s
  - Inclination change ~ 100 m/s
  - De-orbit DV ~ 230 m/s (to get to 3-yr deorbiting orbit)

• Current work: MicroThrust (www.microthrust.eu)
  - FP7 activity with TNO, NANoSpace, QMUL, SystematIc and EPFL
  - Development of a breadboard in 2012, tests in 2013
  - Expected performances > 500 m/s at Isp 3000 s
Vision based systems – current work

• Evaluating motion estimation algorithms
  - 2D: Angles only, optical flow, structure from motion, etc.

• With EPFL Prof. J-P. Thiran’s laboratory, research developments for one 2-D camera and optical flow
  - Algorithms developed, first iteration
  - Current process: creation of representative images, characterisation of algorithm performances

• Hardware implementation
  - Cameras: have discussions with Space-X and with PhotonFocus
  - Evaluation of various CubeSat based computers

C. Paccolat, Master thesis EPFL July 2012
Capture mechanisms – current work

• Three designs in parallel:

1. Underactuated mechanisms
   - Work under/in cooperation with Prof. Lauria, HES-Geneva

2. Dielectric polymer actuators
   - Work under/in cooperation with Prof. H. Shea, EPFL

3. Compliant mechanisms
   - Work in cooperation with F. Campanile, EMPA
Other related activities

- **Mission architecture studies**
  - High level mission architecture tool elaborated within a joint EPFL / MIT master thesis
  - Purpose is to evaluate technology options and mission cost versus mission architecture

- **EC FP7 Call SPA.2013.2.3-02: “Security of space assets from in-orbit collisions”**
  - This call asks for a demonstration mission, which purpose is to perform an in-orbit removal of debris in a low-cost manner
  - SSC proposes (low-cost) platform design

- **Approach and capture test**
  - Student project: 5 Master, 6 semester projects
  - Prototype demonstration of rendezvous maneuvers
  - Test in a swimming pool

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B. Chamot, Master thesis MIT August 2012
Summary *CleanSpace One*

- The Swiss Space Center has started the development of critical and innovative technologies needed for Orbital Debris Removal
- The Swiss Space Center provides an efficient frame for supervising research and tailoring it to space applicable demonstrators
- Swiss Space Center’s plans are meant to be in line with European space agencies and industries
- *CleanSpace One* project in fund raising phase, student team started in September 2012
Thank you
# Vision based systems – current work

## Motion estimation techniques evaluation

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<tr>
<th>Function</th>
<th>Algorithms</th>
<th>Evaluation</th>
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<td>3D imaging technologies</td>
<td>Assumes known orientation of the target</td>
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<td>Assumes depth and space correspondence between sensed points</td>
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<td>Models dynamics of target and predicts pose and orientation accurately up to</td>
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<td>20 s. ahead</td>
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<td>Reasonable performances with measurements at 2Hz: &lt;10% on position, &lt;15° on</td>
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<td>Requires consequent processing capabilities</td>
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<td>2D Cameras</td>
<td>Provides only position and distance of the target</td>
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<td>Long heritage</td>
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<td>Motion estimation only</td>
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<td>Low power requirements</td>
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<td>Implementation available</td>
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<td>Minimal development required</td>
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<td>Can reconstruct depth</td>
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<td>Similar to SLAM (Simultaneous Localisation And Mapping)</td>
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<td>Notable heritage from DARPA challenge</td>
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<td>High computing power required</td>
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<td>Some developments required</td>
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<td>Aghili &amp; Parsa (2008), CSA</td>
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<td>Structure From Motion</td>
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