Vers les drones à ailes battantes

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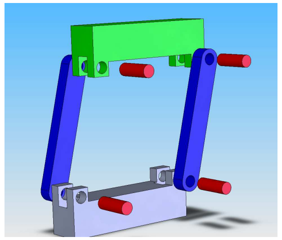
Mécanisme à structure flexible

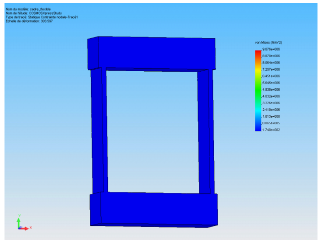
Reaching MONOLITHISM
(structure, actuator, sensor)

Structure : compliant mechanism

Movement and force transmission using elastic deformation



Articulated mechanism

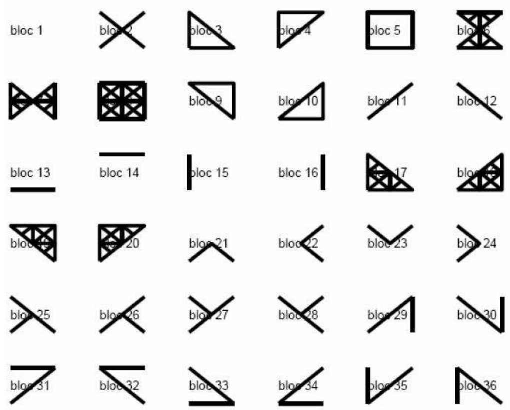


Compliant mechanism

- Advantages
  - No assembly
    - Simplified fabrication and maintenance
  - Never backlash, nor friction
    - Less functional problems (wear, stick-slip)
    - Best reliability
    - Sensibility allowing force measurement (sensorial information)

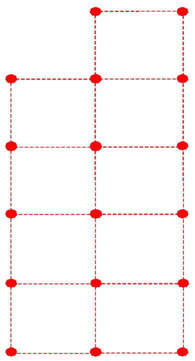
FlexIn : an optimal design numerical tool

- New optimal design method for compliant structures
  (initially developed in coll. with LRP-CNRS)
  - Automatic optimal synthesis using a genetic algorithm
    - True multi-criteria optimization (stochastic operators)
    - Discrete variables (set of structural parameters, etc.)
    - Sequential or simultaneous multi-d.o.f. mechanisms
  - Topology obtained by assembly of building blocks from a library
    (36 blocks)

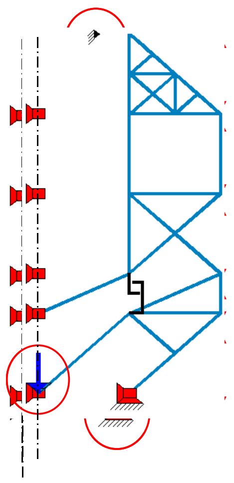


- Model of blocks
  - Navier-Bernoulli beam (rectangular section)
  - Static state calculation
  - Small perturbations
  - Homogeneous and linear elastic material
  - Condensed stiffness matrix (low numerical size)

FlexIn : an optimal design numerical tool

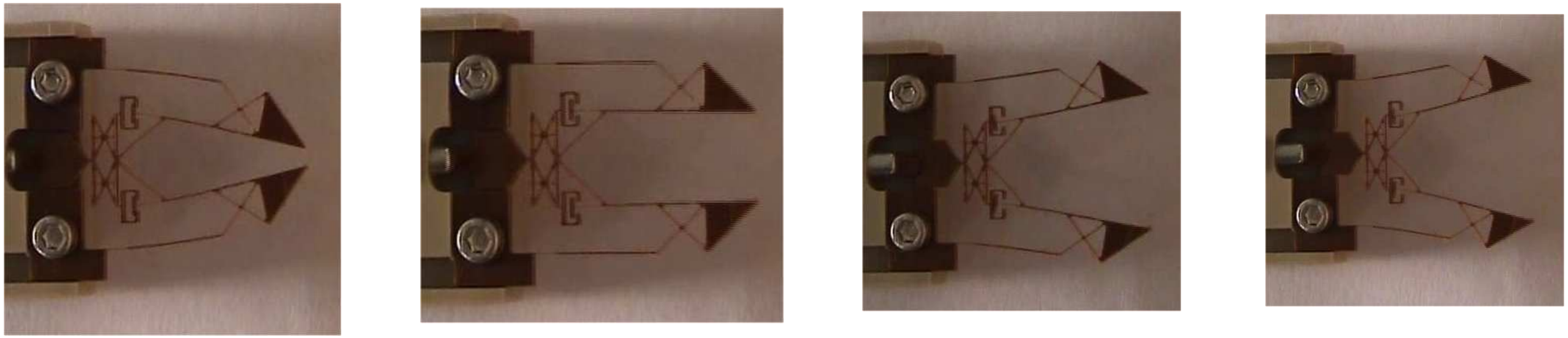


- Fixed values
  - Mesh dimensions (number of blocks, encumbrance)
  - Boundary conditions
  - Output (nodes, direction)
  - Actuator characteristics (stroke, force, stiffness)



- Optimization variables
  - Topology (block type and arrangement)
  - Size of blocks (height, width)
  - Material of each block (and thickness)
  - Nodes fixed to the frame (number and location)
  - External or internal contacts (number, location, backlash)
  - Actuators (number, location, magnitude)
    - Force or displacement actuators
    - External or internal discrete actuators (or distributed PZT)

ILLUSTRATION



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Projets 2007 - 2010

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Listes des projets en cours

- Europe : **IST µDrones**
  - AiRobot + Thales
  - Intervention autonome en milieu urbain
- France : **ANR SCUAV**
  - Bertin technologies
  - Etude amont sur des modules fonctionnels d'intelligence embarquée (suivi de mur, localisation, robustesse du vol, navigation dans modèle 3D)
- France : Pôle de compétitivité Systèm@tic – Projet **Mobisic**
  - Bertin technologies, Sagem, Thales ….
  - Système plug and play et mobile pour la sécurisation d'événements ponctuels
- France FRAE : **Naviflow**
  - Robosoft, UTC, ONERA
  - Evitement d'obstacle par flot optique

Projet FP6 IST µDrones

Development small size flying robot able to carry outdoor missions autonomously without human command for Security & Safety applications

- Autonomous localisation
- Autonomous navigation
- Robustness to unexpected events

<u>Sensors for security</u>

-Vision

-Chemical

<u>Sensors for autonomy</u>

-Vision

-GPS

-Inertial

-US/IR

<u>USABLE IN HUMAN ENVIRONMENT</u>

- Small size and weight
- Careenage

µDrones presentation

CONSORTIUM

- CEA List – Prime - research institute (FR)
- Thales Security System – Industry (Fr)
- University of Tünbingen – Research institute (D)
- AirRobot – SME (D)
- Lisippos – SME (GR)

Budget : 3.5 M€

Duration : 3 Years

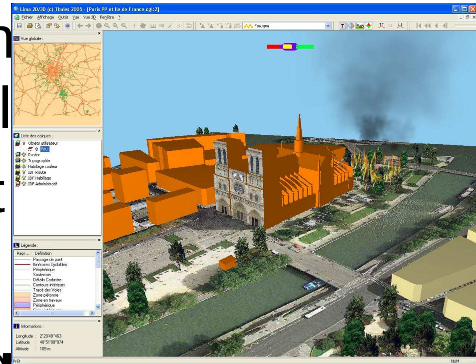
Mains development

Main developments and research axis

- <u>Intuitive MMI for mission preparation and control</u>
  - Thales Security
- <u>Perception and command for flight autonomy</u>
  - CEA List
  - University of Tünbingen
- <u>µUAV development for deployment efficiency and security</u>
  - AirRobot
- <u>Evaluation and validation of concept</u>
  - Lisippos

MCS – Mission Control System specification

- **<u>Man Machine Interface (mission preparation)</u>**
  - Screen with (2D or 3D view of the urban environment (GPS navigation map), to define th trajectory that the drone will follow autonomousl
  - Definition of the trajectory by defining way point
  - Automatic planning of the trajectory



- **<u>Man Machine Interface (mission monitoring)</u>**
  - Display a feedback of :
    - Estimated position of the drone
    - Data coming from the mission sensors (video, chemical …)
  - Stop the drone on an interest point and to servo the drone on this point or command with a joystick

Perception and command for flight autonomy

- Attitude stabilization
  - attitude stabilization of the UAV using inertial sensor (Gyrometer and accelerometer MEMS) to counteract wind perturbation.
  - Careenage
- Localization and navigation
  - Performed by different sensors modalities, including GPS, vision, inertial sensors.
  - Redundancy increases the reliability of the system (loss of information from one of the sensors. (GPS loss, bad vision feedback or too poor video contents).
- Obstacle avoidance
  - Strategy of obstacle avoidance based on optic flow (measurement of time to collision).

– Public Website

- http://www.ist-microdrones.cea.fr

µDRONES

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Conclusions

- Les mini drones constituent une activité de recherche majeure au CEA List
  - Après le développement d'un vecteur et le bas niveaux de la commande, l'essentiel de l'activité est tournée vers les fonctions de localisation / navigation / évitement automatique d'obstacle.
    - Vers le développement de solutions multi capteur associant GPS, Vision, inertiel …
    - Des solutions opérationnelles en GPS seul et Vision + inertiel (sur amer artificiel)
    - Fin 2008 plusieurs technologies multi-capteur de loc/nav en milieu urbain et indoor seront opérationnelles
  - Souhait de lancer une activité drone à aile battante à partir des technologies de mécanisme flexible