Indian Institute of Technology Madras
Department of Engineering Design

Opto-Mechatronics Laboratory — Optical Sensing

Application of Laser Induced Breakdown Spectroscopy (LIBS)

Laser induced breakdown spectroscopy (LIBS) is an analytical tool to find the elemental composition of samples irrespective of their states (solid, liquid or gas). It has several advantages like **multi-element detection**, in-situ analysis, minimal sample preparation, nearly non-destructive, high detection sensitivity and **remote sensing** capability. Forensic elemental analysis, environmental analysis, **space exploration application** and real time radioactive material monitoring are some of the applications of LIBS.

Following LIBS related research topics have been undertaken.

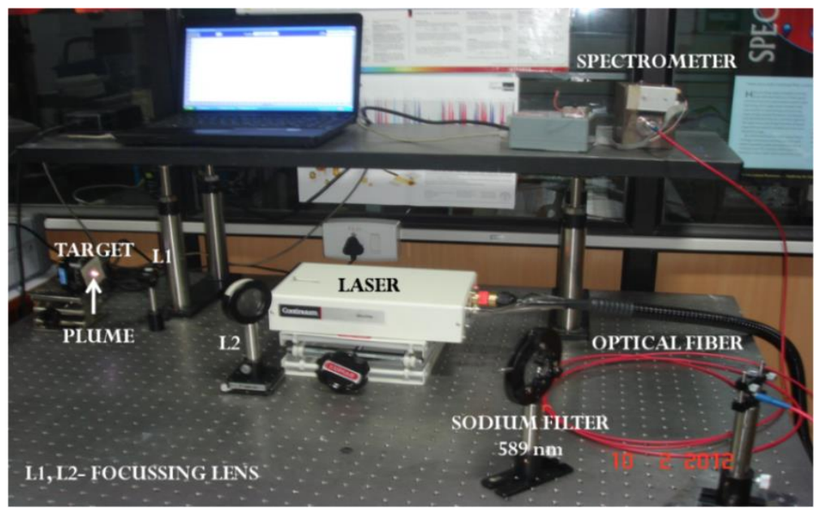
(i) Study on LIBS technique for elemental analysis of lunar soil (2008-2011)
(ii) Study on Remote LIBS: measurement of salt deposit density on wind turbine blade material (2011-2015)
(iii) Study on LIBS technique on diffusion of copper sulphide in oil impregnated pressboard insulation during thermal ageing (2015-2018)
(iv) LIBS for online monitoring of coal (2017 onwards)

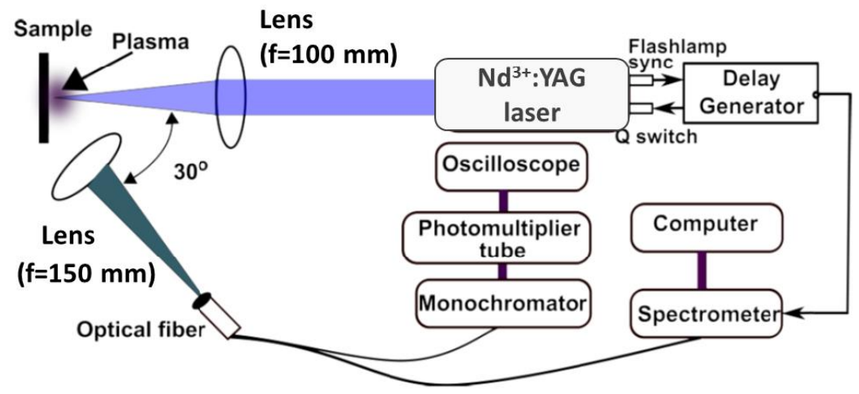
Projects: ISRO (2008-2011), DST (2011-2013), CPRI (2014-2016), UAY: BHEL (2018-2020)

Patent: Indian Patent No. 314839 (Application No.: 4578/CHE/2013, dated 9/10/2013)

Research Team: Jobin K. Antony, V. Sathiesh Kumar, N. Aparna, R. Hemalaxmi, S.Vivek (AM), Della Thomas (OE), N. J. Vasa (ED)

Collaborators: R. Sarathi (EE), Satyanarayanan Seshadri (AM), A. Muruganandam (AE), N. Sujatha (AM), S. Surendran (OE)





LIBS setup developed @ Optomechatronics laboratory

Trace Gas Sensing: Automotive and Biomedical Applications

Techniques applied: Absorption spectroscopy, broadband photoacoustic resonance spectroscopy techniques

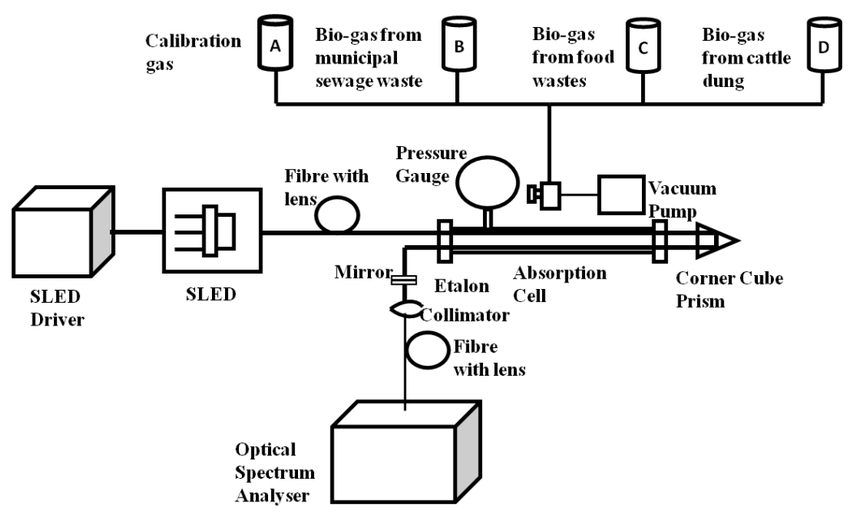
Following research topics have been studied.

(i) Super Luminescent Diode (SLED) Based Absorption Spectroscopy Technique for gas sensing: NH_3, H_2O vapor, CO_2, C_2H_2, CH_4 (2006 onwards)
(ii) Single pulsed laser based Coherent Anti-Stokes Raman Scattering (CARS) technique is demonstrated for simultaneous sensing of CH_4 and CO_2 gases (2011-2014)
(iii) UV Photo-Ionization Based Differential Ion Mobility Sensor for Trace Gas Detection (2009-2014)
(iv) Optical scattering and extinction techniques for measuring concentration of flyash particles in a controlled flow (2014-2016)
(v) Steam dryness fraction measurements combined with Mie scattering (2015 ~)
(vi) Multi-species gas sensing based on electrically tunable fiber Bragg grating using wavelength modulation spectroscopy (2015-2017)
(vii) Development of monitoring system for biogas using broadband photoacoustic spectroscopy technique (2015 ~)

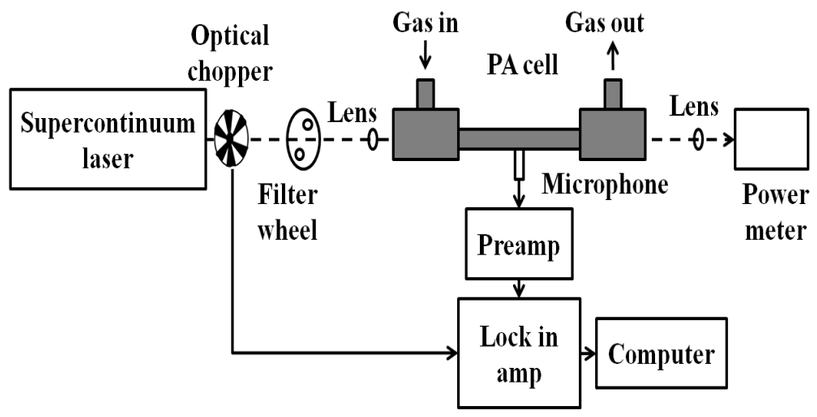
Projects: NFRG@IITM (2006-2008), DRDE (2009-2011), NCCRD (2011-2016), BHEL (2014-2016)

Research Team: K. Divya, K. Sulochana, M. Suresh, Priyanshu, Abdul Nasir K. T., Shivani Tiwari, S. Ramya, Manish Chandra (ID), N. J. Vasa (ED)

Collaborators: M. Kumaravel (CEC), Vivek Agarwal (IITB), Jacob Chandapillai (FCRI) S. C. Eichmann, T. Seeger & Alfred Leipeitz (Erlangen Univ.), S. Balaji (EE), Satyanarayanan Seshadri A(M), S. M. Shiva Nagendra (CE)



Long cell absorption spectroscopy technique @ Optomechatronics laboratory



Broadband photoacoustic spectroscopy Technique developed @ Optomechatronics laboratory

Acknowledgements

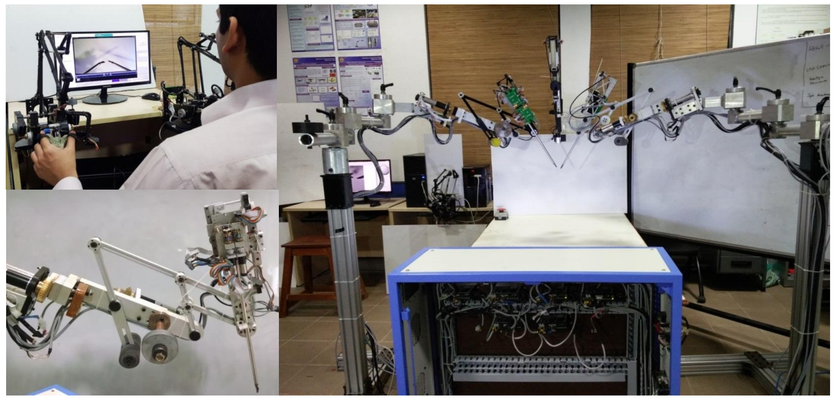
Opto-Mechatronics Laboratory is grateful to High Voltage, PEIL and IC Engine Laboratories and Central Workshop / ED Workshop at IIT Madras, LTT@ Erlangen University, Laser Laboratory@ Kyushu University, and ED Staff members.

M.S. Research Scholars: V. Rajasekar (ME), P. Sundararaman, Dilip K. V. and Dual Degree Students: ED, ME

Indian Institute of Technology Madras
Department of Engineering Design
Open House 2019 – Medical Robotics

Tele-Operated Surgical Robot

Design & Analysis of a Tele-Surgical robot for improved dexterity & performance

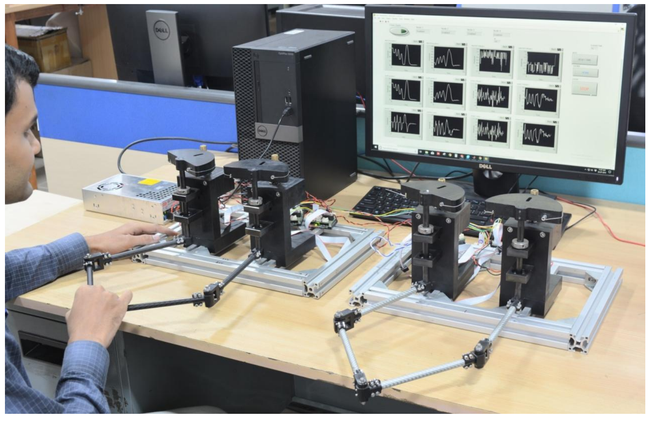


- Electronically tethered master & slave arms
- Scaling of motion & tremor compensation
- Restores lost degree of freedom typically encountered in laparoscopic surgery
- Surgical tool has enhanced dexterity & easier control
- Gravity compensation of all sub systems for added safety
- Compliant mechanism for tool tip aids simpler construction & lubrication free operation in a sterile environment
- Design of single use compliant tool tip to combat bio-fouling

Team members: Karthik C., Suraj P. & Sourav C.

Bilateral Tele-Operation & Control

Control law for maintaining stability & transparency of a Tele-operated system

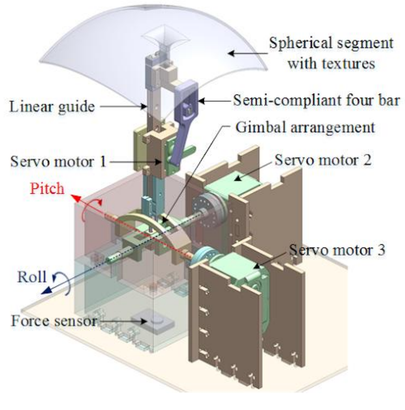


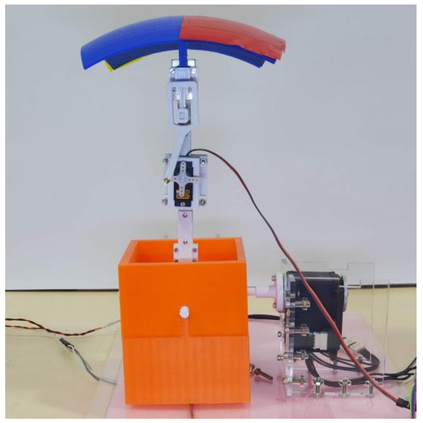
- System equipped with two identical planar manipulators
- Stability & Transparency analysis using a 5 bar manipulator
- Developing 2-channel control architecture.
- Passivity based Impedance controllers developed
- Improved haptic feedback based on transparency study
- Capstan driven for backlash free operation

Team members: Srikar A., Karthik C

Haptic Device

Design and Analysis of a Multimodal Haptic device for rendering stiffness & texture





- Current haptic devices cannot faithfully represent textures along with stiffness
- A spherical segment has multiple textures that can be switched rapidly with a gimbal mechanism
- Tensural flexure for handling higher loads
- By varying the impedance of the mechanism, different stiffness can be achieved
- Applications of this device include palpation of tissues, gaming etc.

Team members: Vijay Kumar P., Srikar A., Karthik C.

For further information please visit Robotics lab – ED 301 (2nd floor)

Prof. Asokan T.

Indian Institute of Technology Madras
Department of Engineering Design
OpenHouse 2019 – Multimodal Robots

Objective: To develop a robot capable of multiple modes of locomotion and/or manipulation, allowing abilities in more than one domain. Multimodal robots are designed to operate in Terrestrial, Aquatic, Aerial, or Scansorial domains.

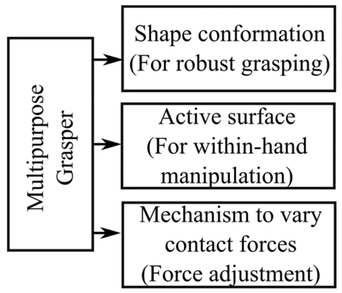
GraspMan: Terrestrial, Arboreal and Manipulation

Introduction:

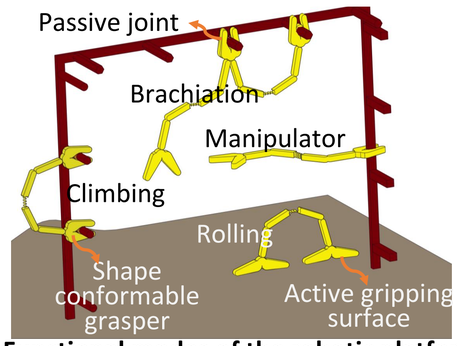
- Grasping, Manipulation, and Locomotion are the main embodiments of a robot to carryout tasks in the physical environment.
- Generally, various modes of such embodiments are achieved at the cost of introducing dedicated mechanisms.

Conceptual Model:

- A multifunctional robot equipped with a pair of novel grasper to synergize Grasping, Manipulation, and Locomotion.
- The multipurpose underactuated grasper has active gripping surface along with shape conformance.

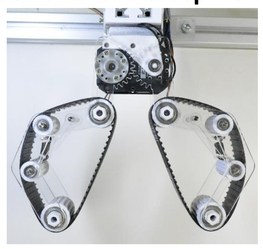


Functional modes of grasper

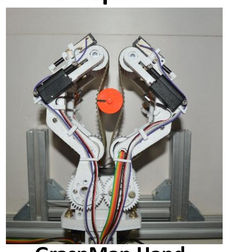


Functional modes of the robotic platform

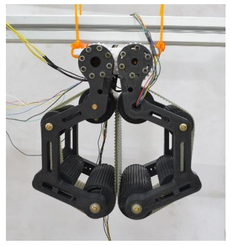
Evaluation from GraspMan hand to GraspMaM:



GraspMan (Conceptual Model)



GraspMan Hand Grasping, WIHM, and Force Manipulation.



GraspMaM Grasping , WIHM, and Locomotion (Active and passive joint)

Shape conformal grasping

Researcher: Nagamanikandan G.

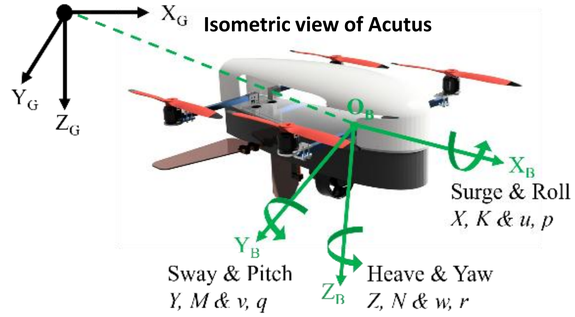
Acutus: Aquatic and Aerial

Introduction:

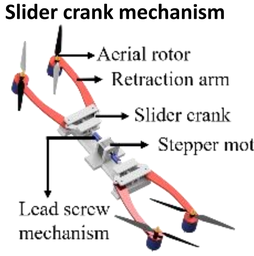
- Aerial and Aquatic vehicles have found vast application like inspection, surveillance, exploration etc.
- Combining these domains to minimize the effort of developing individual system is the main focus of this research.

Conceptual Model:

- Acutus is a remotely operated underwater vehicle with a streamlined fish-like body and for aerial traversal, it uses the configuration of a conventional quadrotor.
- The quadrotor configuration is enabled with a retraction mechanism using which the rotor arms can be retracted inside the body to avoid unnecessary drag during underwater navigation.

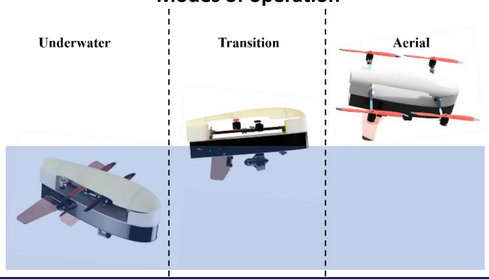


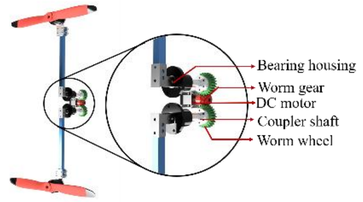
Isometric view of Acutus



Slider crank mechanism

Modes of operation





Drive mechanism for retraction of quad rotor arms

Researcher: Thiyagarajan R.

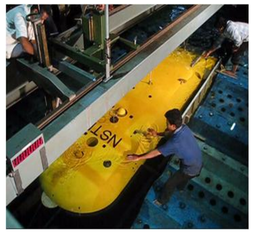
Indian Institute of Technology Madras

Department of Engineering Design

OpenHouse-2019

AUTONOMOUS UNDERWATER VEHICLE

- AUV is a 6-DoF autonomous submersible vehicle which can be controlled and navigated to accomplish underwater tasks.
- Movements in 6 DoF — surge, sway, heave, pitch, roll & yaw can be achieved by propellers placed suitably. Besides rudders and stern planes can also be used for control.
- The robotic vehicle is fully pre-programmed and piloted by an onboard computer.
- A potential field obstacle avoidance algorithm steers the vehicle underwater.
- Design of control algorithms for navigation and guidance of AUV is crucial for AUV operation.

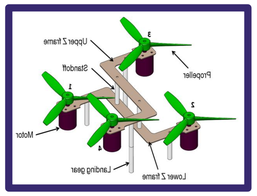


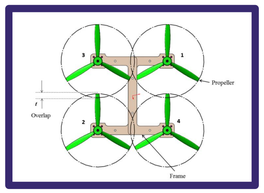
Aerial Robot- VOOPS

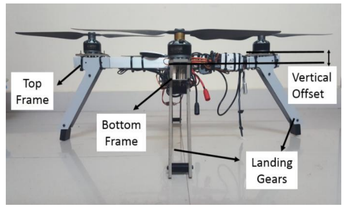
- In recent years, micro aerial robots have gained wide attention and are being developed for various applications.
- Multi-rotors are simple and most reliable due to absence of complicated mechanisms to steer them.
- The critical parameters are its size, payload carrying capability and endurance.
- Enhancing any of these parameters will elevate the performance of the system. **VOOPS**- **V**ertically **O**ffset **O**verlapping **P**ropulsion **S**ystem enhances payload carrying capability and endurance without increasing the footprint.

Advantages

- Accommodates a larger propellers for the same size.
- Better endurance and payload lifting capability for the same size.

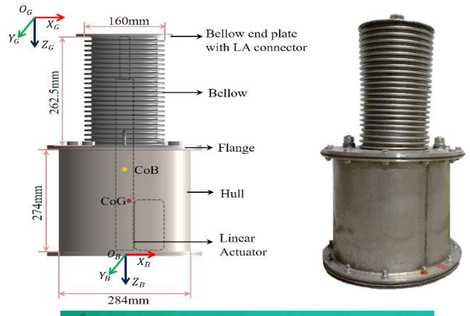






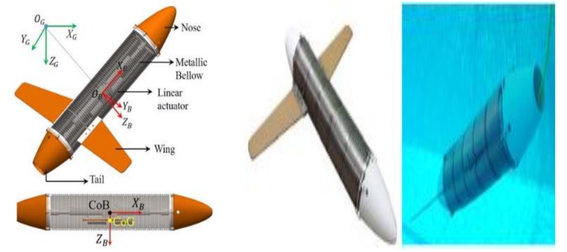
vBuoy

- vBuoy is an integrated structure of a rigid hull and a metallic bellow whose volume can be varied using the linear actuator housed inside the sealed integrated structure.
- Imbalance in the natural forces like the buoyancy and weight on an object can be effectively used to achieve motion across the water column.
- By expanding/compressing the metallic bellow, the buoyancy is varied and there by the heave motion can be achieved.
- Overall dynamics of vBuoy can be divided to three subsystems namely, Linear actuator sub system, Fuselage subsystem and Wing subsystem.



Underwater Glider: RoBuoy

- A novel underwater glider based on the concept of vBuoys is a RoBuoy.
- It uses minimal number of parts and all the vital parts of RoBuoy required for its working are enclosed inside the hull, there by increasing the durability.
- By vectoring the residual buoyancy (difference between weight and buoyancy) using wings, surge motion can be achieved. With the current design, two modes of operation are possible.



Principle of Working:-