SENS i-Lab

Principal Investigator:
prof. Massimiliano MASULLO

Responsible for teaching and research activities in the laboratory (R.a.d.o.r.):
prof. Massimiliano MASULLO (proposed at the CdD of 13 February 2020)

Location:
Il laboratorio è ubicato presso la sede del Dipartimento di Architettura e Disegno Industriale, Abazia di San Lorenzo, Aversa, al piano terra.

Main Laboratory Activities:
SENS-i Lab is a human-centred, multi-physical and multi-purpose laboratory for creating, developing, prototyping, and human interaction with physical and virtual products and systems. The laboratory is configured as an Experimental Center of Smart Design and Assessment. It is in line with the Strategia Nazionale di Specializzazione Intelligente (SNSI)'s long-term investment priorities and with the Italian National Plan Industria 4.0.
Starting from the information of measurements/surveys and the conceptualisation/modelling phases, it is possible to prepare and carry out, in vivo or in virtual, subjective tests where the human experience of urban/rural or industrial environments, architectures and products, can be measured during the development phases of the projects by psychophysiological and behavioural reactions.
The key aspect of SENS i-Lab is creating a holistic experience, through the multi-stimulation of different sensory channels and an ecological interaction with the experimental environment.
From the didactic point of view, it is possible to set up demonstration scenarios supporting the development of new methodologies, based on learning by doing and action learning. In the field of architecture, projects related to different architectural solutions can be evaluated by the designers' direct and immersive experiences, or in co-design, as to develop retrofitting techniques during the early stages of the design. Thanks to the different physical stimuli reproducible in the Integrate Test Room, disadvantages and advantages of using traditional and innovative design techniques can be studied with the same approach. It is also possible to study and develop workflows for the Design 4.0 of products for Industry, Fashion and Communication.
In addition to the use for educational purposes, the laboratory aims to be the development and experimentation space of scientific research fields of different disciplines, including:

- Development of Co-Design / Participatory Design models;
- Development of new paradigms for the evaluation of architectural and urban projects;
- Study of the interaction between individuals and physical variables of artefacts;
- Prototyping;
- Development of smart design protocols;
- Studies on the environmental comfort of individuals;

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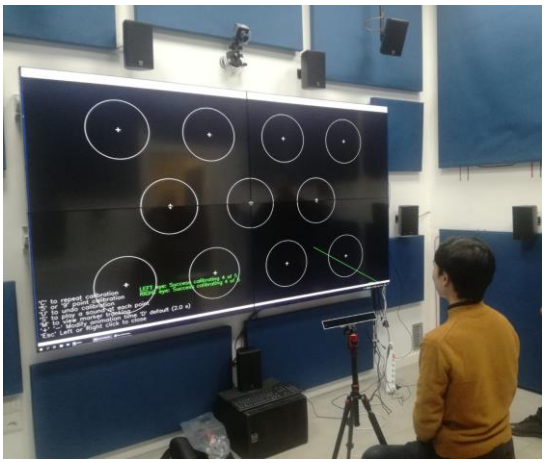
- Development of multi-sensorial impact assessment man / environment protocols, in existing / project scenarios on a territorial or urban scale;
- Design of scenarios (virtual / real) of significant cultural or environmental interest;
- Determination of subjective environmental response models, for the purpose of determining overall comfort (thermo-hygrometric, IAQ, acoustic, vibrational, visual and luminous) inside indoor spaces, transportation and outdoor;
- Experimental characterisation of performance associated to hydronic and aeraulic terminals upon varying the boundary conditions;
- Experimental characterisation of component and systems for the development and application of a methodology devoted to fault analysis, fault detection and fault identification of heating, ventilation and air-conditioning plants by means of dynamic simulation models and artificial intelligence techniques;
- Experimental characterisation of indoor air quality through the measurements of CO, CO_2 and VOC concentrations as well as mass and dimension of PM1, PM2.5 e PM10;
- Studies on the interaction between physical stimuli and eye movements for product design, marketing and complex models.

Main Equipment:

Multisensory Test room composed by the following main systems and components:



Audio 3D:

Astro Spatial Audio combines Spatial Sound Wave (SSW) technology, developed by the Fraunhofer Institute for Digital Media Technology IDMT, and licensed to ASA, with the intelligence and power of the SARA II Premium Rendering Engine to bring a sophisticated spatial sound platform to the sound engineer.

The result is the main independent solution for scalable and fully object-based immersive audio. The system is composed of:

- n.1 - SARA II Premium Rendering Engine;
- n.1 - Amp Innosonix MA32/D 32;
- n.25 - Adorn A55 Martin Audio - Ultra-compact passive two-way system, front ported bass reflex, freq. resp. 90Hz-17kHz ± 3dB, driver LF: 5.25” /1” high-temp voice coil, HF: 0.75” silk dome, neodymium motor, 50W AES, 200W peak, max SPL 113dB peak;

- n.2 - Sx110 Martin Audio - slimline subwoofer, freq. resp. 50-150 Hz ± 3dB, driver 1x10"/2" voice coil, 250W AES, 1000W peak, maximum SPL 121dB continuous, 127dB peak (half space);
- Dante Virtual Soundcard;
- Dante Controller Software;
- Astro Spatial Audio Suite: Playout application, Production application, Enhanced production editor, Automation manager, Cuemanager, RSMPro application;
- Avid Protools 12 Software.

Videowall

The system is composed of:

- n.4 LCD panels KVD5521B 55" Full HD resolution (1920 x 1080) High performances, illuminance (500 cd/m² nominal), 1400:1 contrast and automatic colour and brightness calibration system;
- n.1 NSD410 controller based on IP architecture with 4 DVI inputs and 4 DP outputs. Intel I7 6800K 12-core 3,40 GHz Processor, NVIDIA Quadro M4000 Graphic card.

Lighting system

The system consists of 6 ceiling mounted LED lighting luminaires (luminaire wattage: 50 W and luminous flux: 4600 lm). The luminaires are dimmable (illuminance level on the laboratory centre ranges between 50 lux and 800 lux on a reference plane at 0,75 m with respect to the floor) and allow to vary the correlated colour temperature of the emitted light between 3000 K and 5800 K. An occupancy sensor and two illuminance sensors are also integrated into the system. Luminaires can be controlled manually and through an automatic luminous flux control system for maintaining a set illuminance level within the laboratory.

Microclimate

Hydronic air-conditioning system for controlling the dry-bulb temperature (in the range 15 °C÷35 °C) and the mean radiant temperature of the test-room. The following main components and instruments are used:

- n.1 13,7 kW vapor-compression electric heat pump;
- n.1 13,7 kW vapor-compression electric refrigerating system;
- n.2 sensible thermal energy storages with a volume of 300 litres equipped with 2 internal heat exchangers;
- n.1 radiant floor of the test room;
- n.2 radiant vertical walls of the test room;
- n.1 fan-coil with a nominal heating capacity of 11,2 kW and nominal cooling capacity of 8,1 kW;
- n.2 variable-flow pumps operating up to 12 m³/h while supplying the radiant panels and the fan-coil;
- n.2 volumetric flow-meters operating in the range 0÷1,5 m^3/h with an accuracy between 0,25% and 0,7% of readings;
- n.1 volumetric flow meter operating in the range 0÷10 m^3/h with an accuracy between 0,25% and 1,4% of readings;

- n.12 Pt100 resistance thermometers (class of accuracy 1/10 DIN) operating in the range 0 °C÷100 °C;
- n. 1 watt-meter measuring an alternating voltage up to 280 V together with an alternating current intensity up to 2 A;
- n. 1 differential pressure transducer operating in the range 0÷250 mbar with an accuracy between 0,075% and 0,15% of readings;

Heating, Ventilation and Air-Conditioning system able to control the dry bulb temperature (in the range 15 °C÷35 °C), the relative humidity (in the range 25%÷95%), the indoor air quality as well as the indoor air velocity in the test room operating with a maximum volumetric flow rate of 600 m^3/h. The system is composed of the following sub-components and instruments:

- n.2 filters of efficiency class G4;
- n.1 filter of efficiency class F9;
- n.1 heat recovery system with counterflow heat exchanger characterised by a nominal capacity of 3,1 kW;
- n.1 finned coil heat exchanger for air pre-heating with a nominal capacity of 4,1 kW supplied by a 13,7 kW vapor-compression electric heat pump;
- n.1 finned coil heat exchanger for air cooling and dehumidification with a nominal capacity of 5,0 kW supplied by a 13,7 kW vapor-compression electric refrigerating machine;
- n.1 finned coil heat exchanger for air post-heating with a nominal capacity of 5,0 kW supplied by a 13.7 kW vapor-compression electric heat pump;
- n.1 air humidifier with a nominal capacity of 3,7 kW able to provide up to 5,0 kg/h of steam water.
- n.2 sensors for measuring the dry bulb temperature (in the range 0 °C÷50 °C with an accuracy of ±1 °C) together with the relative humidity (in the range 0÷100% with an accuracy of ±5%) of air flows;
- n.2 sensors for measuring the dry bulb temperature (in the range -50 °C÷50 °C with an accuracy of ±0.9 °C) of air flows.

Motion Tracking System.

The system is part of the category of optical tracking systems with the help of passive markers. The optics are installed in order to be able to track the markers at every point of the practicable space inside the Testing Room. With this system it is possible to track with extreme precision the movements of each single marker and consequently the movements of the bodies to which the markers are attached, whether they are human in nature or rigid bodies. Thanks to wearable elements such as overalls, gloves, knee pads and helmet it is possible to completely map the body of a user and create the related system of points that configures the virtual skeleton. The acquired data can be recorded for subsequent analysis, can be uploaded to avatars, or transferred in real-time to development platforms for VR applications. The system is composed of:

- n.8 Vicon Vero 2.2 optoelectronic cameras, 2.2 MP 2048x1088;
- n. 2 Vicon Vue cameras, 2.1 MP 1920x1080 RGB;
- Set of reflective markers consisting of over 100 units;
- A computer / server that receives the images from the cameras, extracts the markers from the images and reconstructs their three-dimensional positions;
- Vicon Nexus software;

- Vicon Tracker software.

VR Head Mounted Display
- HTC Vive Pro;
- HTC Vive Pro Eye;
- Oculus Rift-S;
- Oculus Go.

Measurements on persons and biofeedback
- Eye tracker for desktop Gaze Point;
- Portable eye tracker glasses Pupil lab;
- VIVE Pro Eye VR.
- Wearable systems equipped with biosensors Equivital for measurement of the Galvanic Skin Response (GSR), heartbeat (ECG) and respiratory rate.
- Software Labchart.
- DSI 24 Wearable Sensing EEG Headset.
- Portable electronic nose Cyranose 320
- System for surface temperature measurement.
- System for the temperature, relative humidity and the air velocity measurement near the body (Candlestick Sensor from Advanced Thermal Solutions, Inc.).

IAQ
The following instruments are available for measuring the indoor air quality:
- n.1 TSI Q-TRAK model 7575 equipped with 982 probe for real-time measuring the concentrations of CO and CO_2, together with the indoor dry bulb air temperature and relative humidity. The instrument has the following characteristics:
  Range: 0÷500 ppm CO, 0÷5000 ppm CO_2, 5÷95% RH, -10÷60°C;
  Accuracy: ±3% of reading or ±3 ppm CO, whichever is greater; ±3% of reading or ±50 ppm CO_2, whichever is greater; ±3% RH; ±0.5°C;
  Resolution: 0,1 ppm CO; 1 ppm CO_2; 0,1% RH; 0,1°C.
- n.1 TSI Q-TRAK model 7575 equipped with 984 probe for real-time measuring the concentration of VOC and the indoor air dry bulb temperature. The instrument has the following characteristics:
  Range: 10÷20,000 ppb, -10÷60°C;
  Accuracy: ±0.5°C;
  Resolution: 10 ppb; 0,1°C.
- n.1 TSI DUSTTRAK™ DRX model 8533 for real-time measuring of size-segregated mass fraction concentrations corresponding to PM1, PM2.5, Respirable, PM10, and Total PM size fractions. The instrument has the following characteristics:
  Particle Size Range: 0.1÷15 μm;
  Resolution: ±0.1% of reading or 0,001 mg/m^3, whichever is greater.

Other equipment:
- Net Irradiance Meter LP NET14: 4-component net-radiometer (0.3μm - 45 μm);
- 3D impulse response system for architectural acoustics;

- Dodecahedron Loudspeaker with AMPLI12;
- 3D printer.

Software:

- Origin Pro 2021;
- Artemis suite;
- MATLAB 2019 b;
- Lab Chart 8 AD Instrument;
- LabVIEW Suite: LabVIEW Full Development System 2019 SP1, LabVIEW Application Builder 2019 SP1, Vision Acquisition 2019, LabVIEW Real-Time Module 2019, LabVIEW FPGA Development Module 2019, Sound and Vibration Assistant 1.0, Sound and Vibration Measurement Suite 2019, Sound and Vibration NXG Measurement Suite 2.0, Sound and Vibration Toolkit 2019.
- EyeCAD VR;
- Rhinoceros 6.

Associated Research Groups:

- ACOUVI - Acoustics, Vibration and Multisensory Interactions;
- E3 - Energy Efficiency & Environment;
- ADMALAB - Advanced materials Laboratory;
- StandardF-AU;
- REST;
- BIM technology and material innovation: from efficiency to environmental compatibility;
- SU.RE;
- The form of Architecture and Design in the settlements, in the landscape and in the inner space;
- Another planet earth: architecture and revolution;
- Theories and practices of architecture in the contemporary age;
- HIDEeG2;
- PCC;
- MemoS;
- L.A.N.D.;
- Construction site / City
- The System. Architectures and infrastructures for digitisation
- SIDE;
- ZEB twd ZEEB;
- Drawing, Survey, Representation, Structure, Communication of cultural heritage.

Reference Scientific Subject Areas:

ING-IND/11; ICAR/08; ICAR/09; ICAR/12; ICAR/13; ICAR/14; ICAR/17; ICAR/18; ICAR/19; ICAR/20; ICAR/21; ICAR/22; IUS/10; ICAR/08; L-ART/06; SECS-P/08.

ISI WEB categories:

- Computer Science, Software Engineering;
- Engineering, Environmental;

- Engineering, Multidisciplinary;
- Acoustics;
- Physics, Multidisciplinary;
- Engineering, Manufacturing;
- Psychology Multidisciplinary;
- Public, Environmental & Occupational Health;
- Computer Science, Artificial Intelligence;
- Computer Science, Hardware & Architecture;
- Computer Science, Interdisciplinary Applications;
- Urban Studies;
- Education & Educational Research
- Multidisciplinary Sciences.

ERC categories:

- PE2 14 - Thermodynamics;
- PE7 3 - Simulation engineering and modelling;
- PE8 6 - Energy systems (production, distribution, application;
- SH2 6 - Sustainability sciences, environment and resources;
- SH3 1 - Environment, resources and sustainability;
- SH3 8 Mobility, tourism, transportation and logistics;
- SH3 9 Spatial development and architecture, land use, regional planning;
- SH3 10 Urbanisation, cities and rural areas;
- SH4 4 Cognitive and experimental psychology: perception, action, and higher cognitive processes;
- SH5 11 Cultural heritage, cultural memory;
- SH5 5 Visual arts, performing arts, design;
- PE2 12 Acoustics;
- PE6 1 Computer architecture, pervasive computing, ubiquitous computing;
- PE6 8 Computer graphics, computer vision, multimedia, computer games;
- PE6 9 Human computer interaction and interface, visualisation and natural language processing;
- PE6 11 Machine learning, statistical data processing and applications using signal processing (e.g. speech, image, video);
- PE6 12 Scientific computing, simulation and modelling tools.

Key words:

Multisensory Design; Co-Design; Smart Design; Environmental Impact Assessment; Virtualisation; Worker safety; Virtual training; Cultural Heritage; Environment; Psychoacoustics; Multisensory perception; Lighting; Smell; Comfort; Product sound quality; Eye tracking; Bio-feedback; Predictive maintenance; Indoor air quality assessment; Rating of thermal indoor environment; Quantification of an emission source; Modelling and simulation of HVAC systems. Architecture; Sustainability; Urban Studies; Buildings.