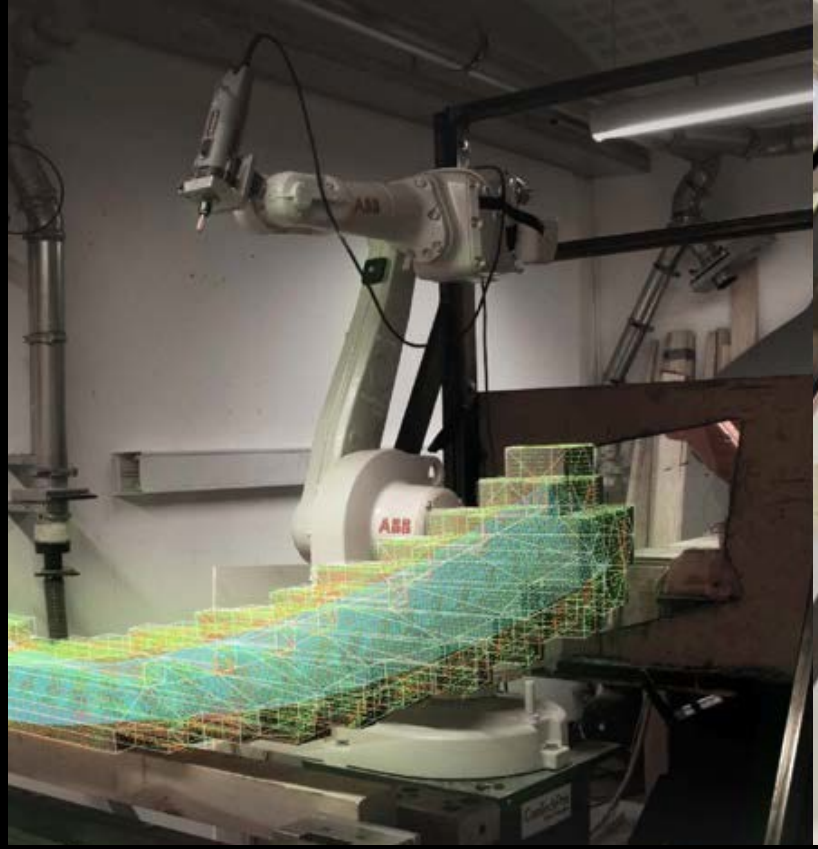
Predicting Response

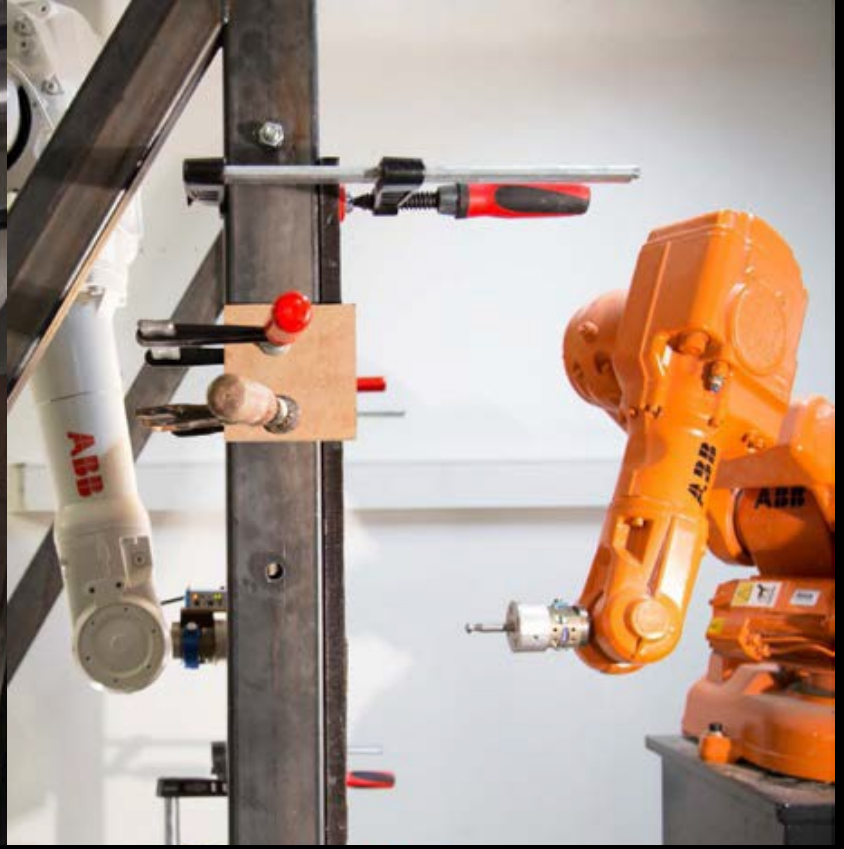
Paul Nicholas
Lektor, IBT

Lifestile og Design Cluster
Materiale innovation | Bio-polymerer | 03.12.2020

WHAT IS CITA

CITA



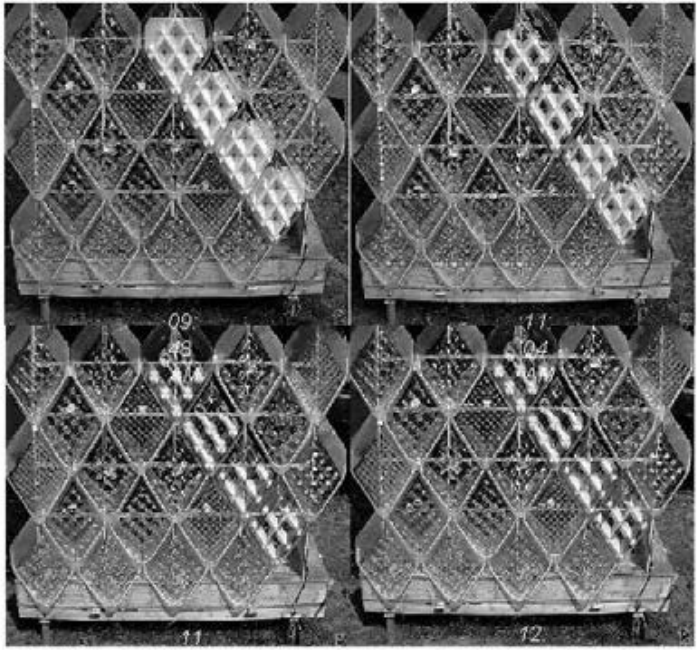


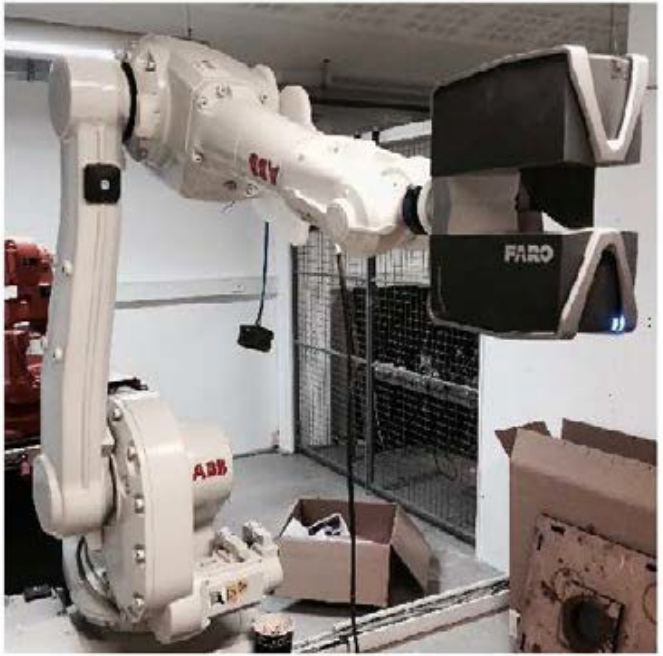
ROBOTIC FABRICATION

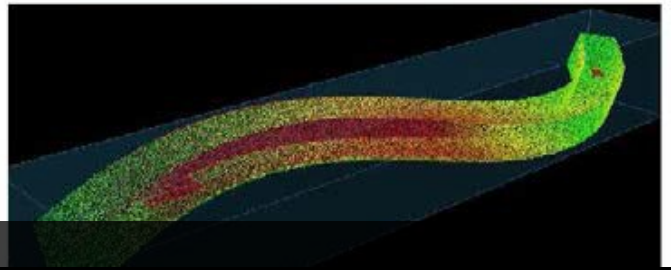
CITA

NEW MATERIAL PROCESSES

CITA

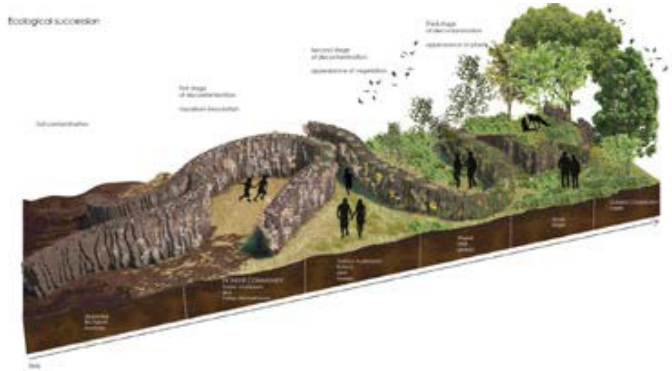


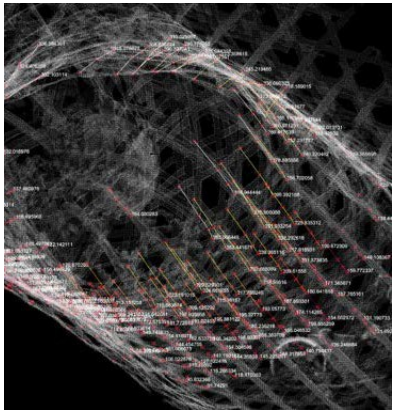




BIG DATA AND MACHINE LEARNING

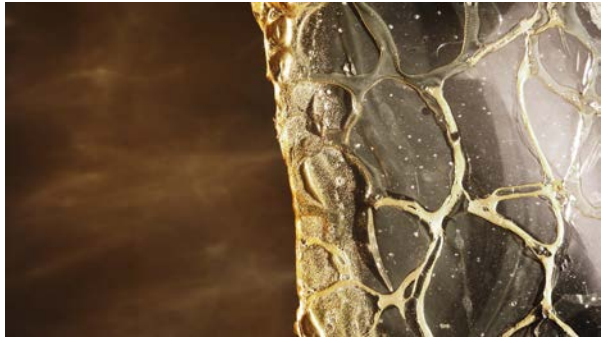
CITA

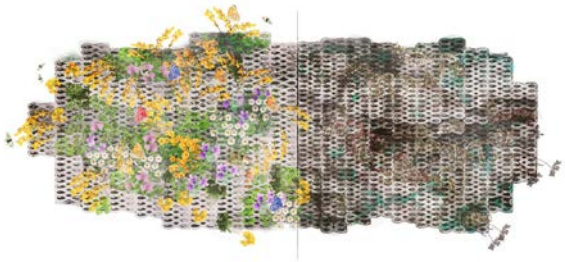


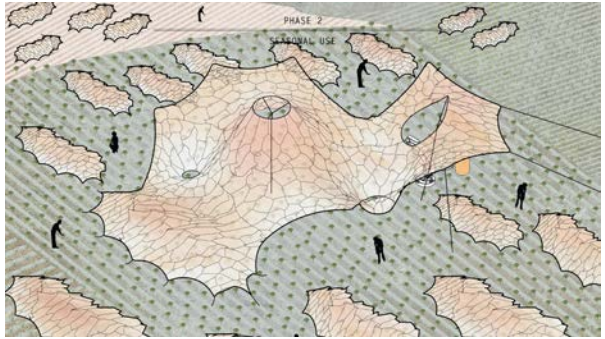


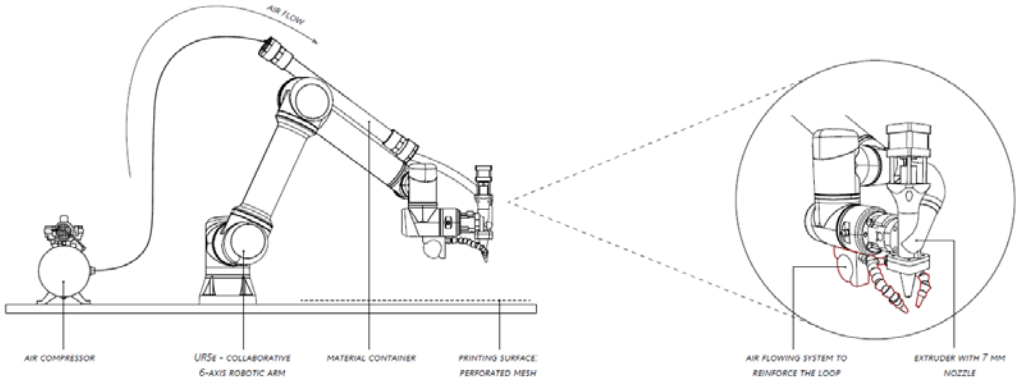
MASTERS COMPUTATION IN ARCHITECTURE

CITA






PHASE 2
SEASONAL USE


AIR FLOW
AIR COMPRESSOR
UR5e - COLLABORATIVE 6-AXIS ROBOTIC ARM
MATERIAL CONTAINER
PRINTING SURFACE: PERFORATED MESH
AIR FLOWING SYSTEM TO REINFORCE THE LOOP
EXTRUDER WITH 7 MM NOZZLE

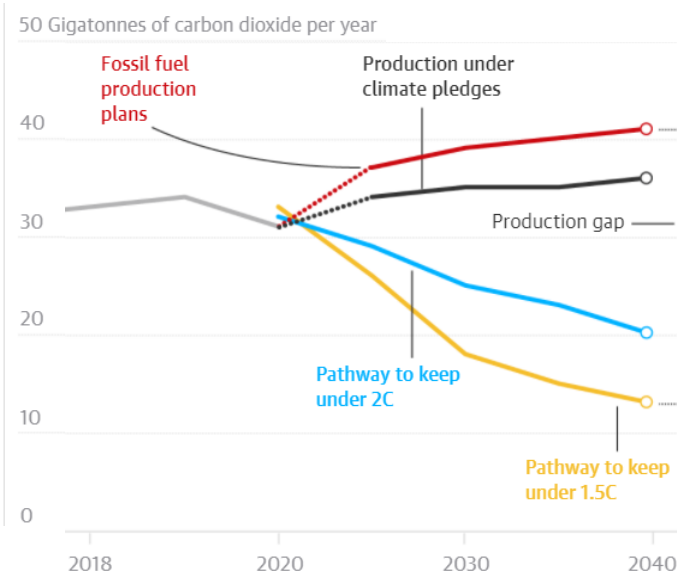
In Europe, 30-50 percent of total material use goes into construction with 65 percent of these being aggregates and 20 percent metals.

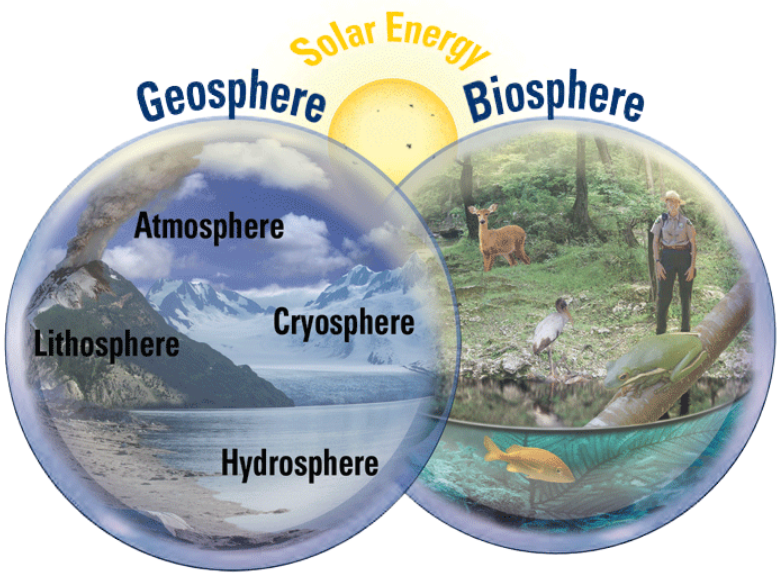
CRISIS OF SUSTAINABILITY: POPULATION GROWTH AND URBANISATION

INDUSTRIALISED FABRICATION HAS FOCUSSED MATERIAL PRACTICE ON A SUBSET OF VERY SPECIFIC MATERIALS

WHERE WE FIND OURSELVES DROWNING IN PLASTIC... *Juhu Beach, Mumbai*

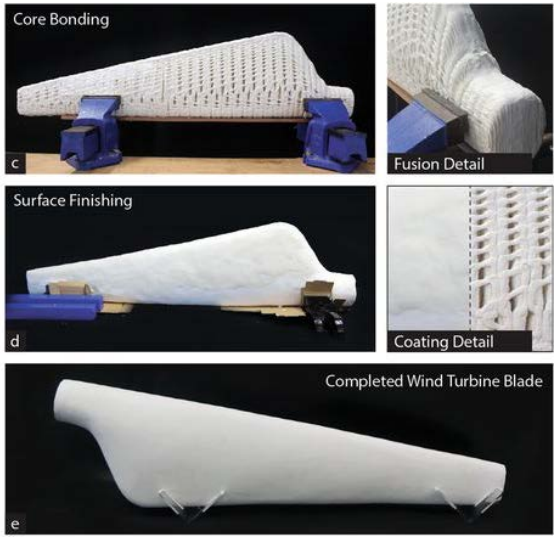
...WE ARE RUNNING OUT OF BASIC AGGREGATES AND MINERALS...





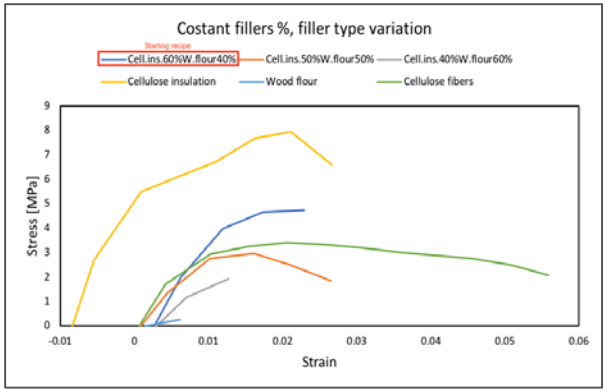
FROM A DEPENDENCE ON THE GEOSPHERE OF NON-RENEWABLE MATERIALS TO THE BIOSPHERE OF RENEWABLES

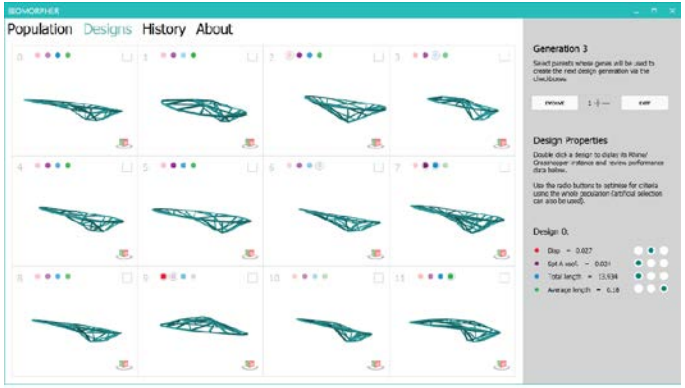
MIT



SUTD

A GROWING FIELD OF ARCHITECTURAL RESEARCH





Royal Danish Academy
Architecture Design Conservation

CITA

Project Lead, Sensor system, Machine Learning, AM Process, Design

Mette Ramsgaard Thomsen, Paul Nicholas, Martin Tamke CITA
Gabriella Rossi PhD, CITA 36 month
PostDoc, CITA (30 months 50%)
Claudia Como, Ruxandra Stefania Chiujdea, RA, CITA

DTU Technical University of Denmark

Department of Chemical Engineering

Material Design, Material Testing

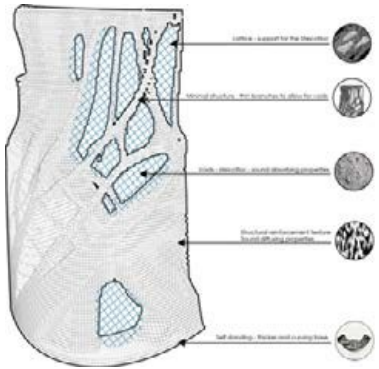
Anders Egede Daugaard, DTU
Arianna Rech, DTU 36 month / 12 month funding by PR

University of Reading

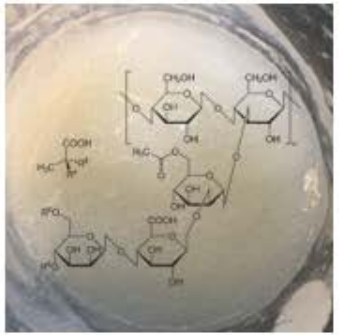
School of Architecture

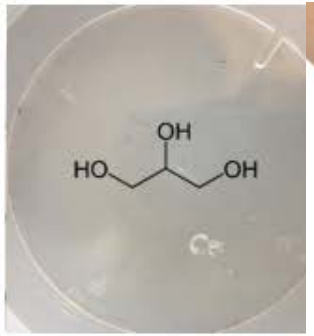
Machine Learning, Design Integration

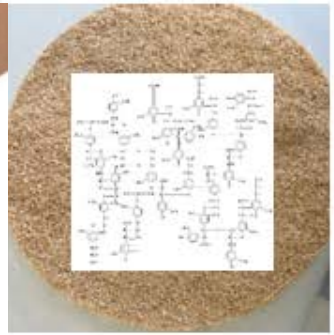
John Harding, Reading



AIM: TO DEVELOP RECIPES AND METHODS THAT ENABLE FABRICATION OF ARCHITECTURAL SCALE OBJECTS







Xanthan gum
biopolymer

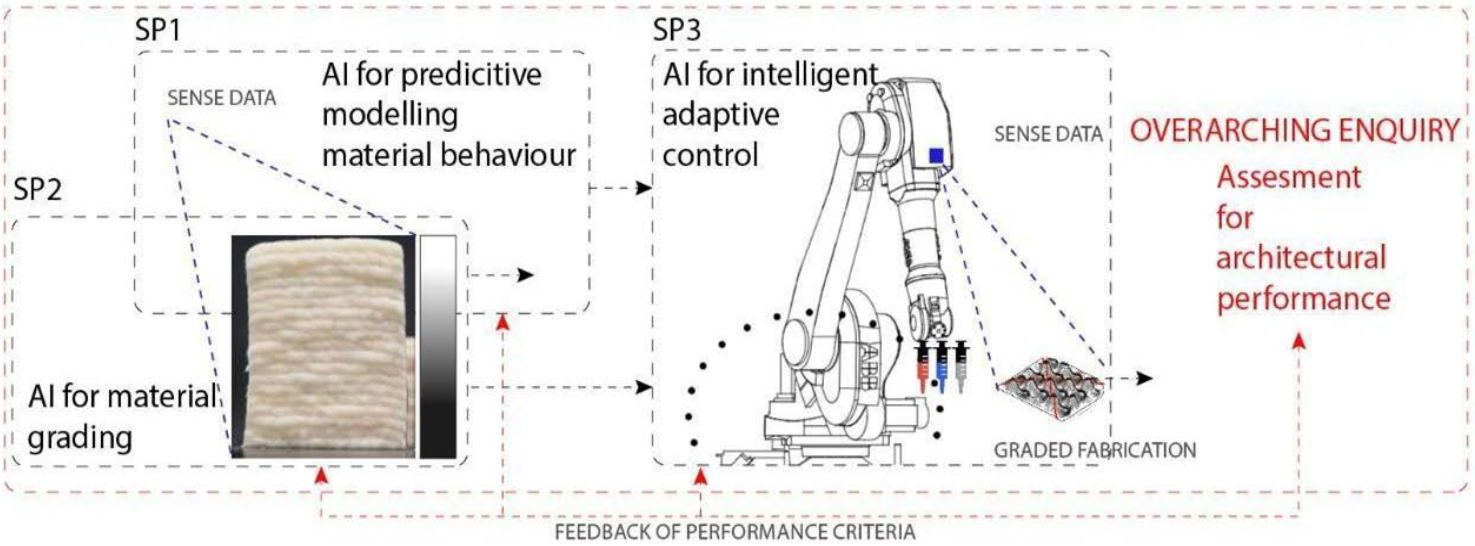
Glycerol
plasticizer

Cellulose
insultation

Wood flour
filler

Water
solvent

SLURRY BASED BIOPOLYMER



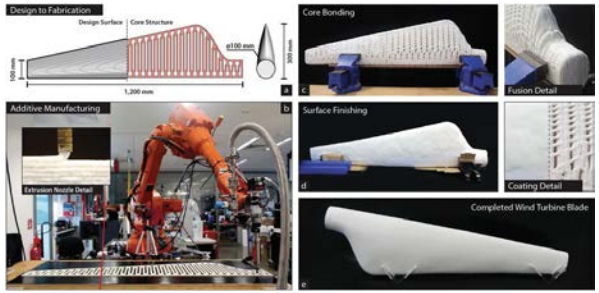
PROJECT DESIGN

SP1: Predictive modelling of material behaviour of slurry printed biopolymers

...Subproject 1 develops models that predict material transformation during setting and final structural performance. By using external sensing (LIDAR scanning and machine vision), the use of Convolutional Neural Networks (CNN) will be investigated to predict the complex geometric transformations that result from material grading and the configuration of fabrication parameters….

Gabriella PhD, CITA

The PhD assembles suitably wide and informed datasets to train the models and examines a broader array of neural networks against which the performance of the CNN methods can be assessed. She will examine their capacity for prediction and integration into design workflow. Gabriella has strong computational design skills and special knowledge of machine learning for architecture.

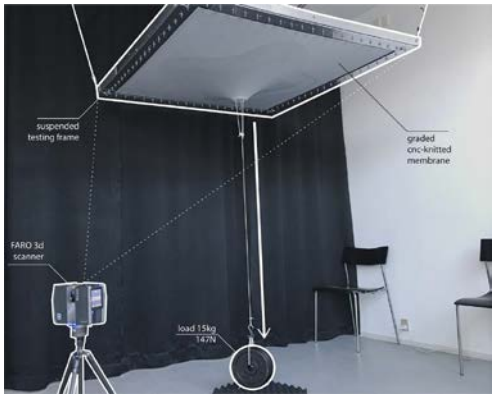


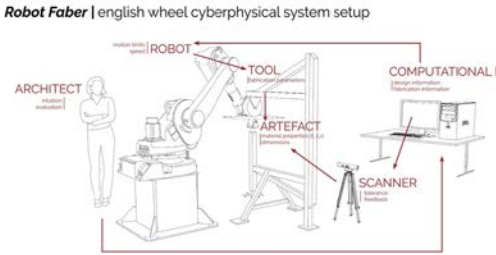
SP2: Predictive modelling for grading of biopolymer composition

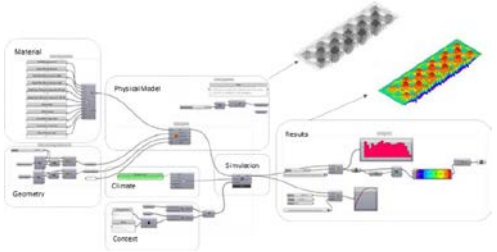
….Subproject 2 defines the constituent materials, the dimensionality of their combination and the non-linearity of their grading and resultant properties. It will generate material characterisation data through tensile and compressive testing of material samples, and compare the capacity of Support Vector Machines (SMV), Artificial Neural Networks (ANN) and Random Forests (RF) to capture and predict how varying constituent ingredients and their proportions, together with processing parameters impact upon a material's structural and performance….

PhD/PD, DTU

The Postdoc investigates and defines varying material recipes, processes samples of the specified materials and generates material characterisations relevant to desired performances for architectural application. The focus is to generate material recipes and associated datasets of performance and to train and test the classification and predictive capacity of the identified machine learning algorithms.





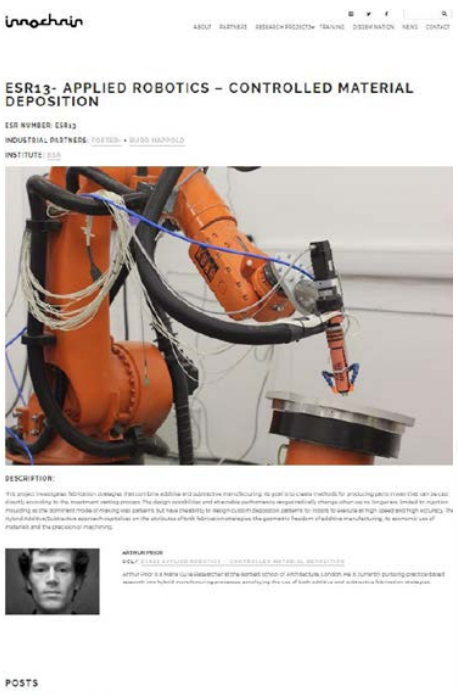


SP3: Design integrated intelligent adaptive control for biopolymers

….Subproject 3 develops intelligent adaptive fabrication processes for 3D printing biopolymers, with the aim of achieving a better interaction between fabrication and material parameters…...The subproject will explore the use of machine learning models to incorporate sensed material behaviour into the process of specifying robotic fabrication commands.

PD, CITA

The Postdoc investigates adaptive control mechanisms that respond to data sensed during the fabrication process. It will test application of models that process time-series data based on LTSM methods and Markov chains, as well as Artificial Neural Networks where shallow and deep learning has been shown as particularly successful to both visual processing and adaptive robotic control. The aim is to integrate the forecasting of time-series data with adaptive control and create print paths on-the-fly.



Water

Glycerol

Glycerol 1%
Water 79%

Glycerol 8%
Water 73%

Glycerol 24%
Water 55%

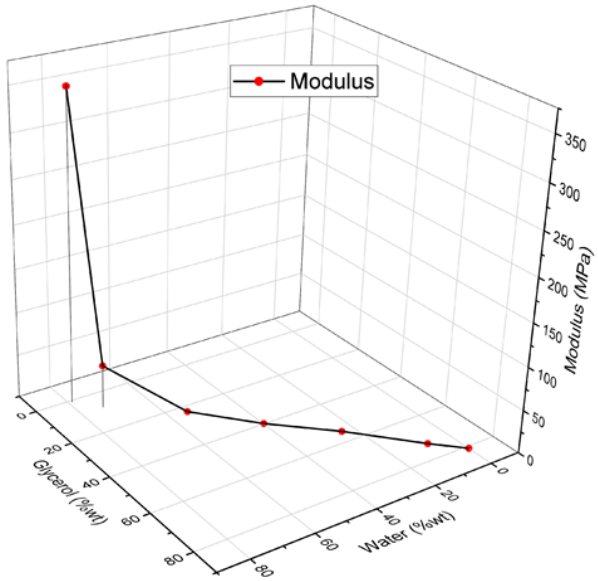
Glycerol 40%
Water 40%

Glycerol 55%
Water 24%

Glycerol 73%
Water 8%

Glycerol 81%
Water 0%

Initial recipe



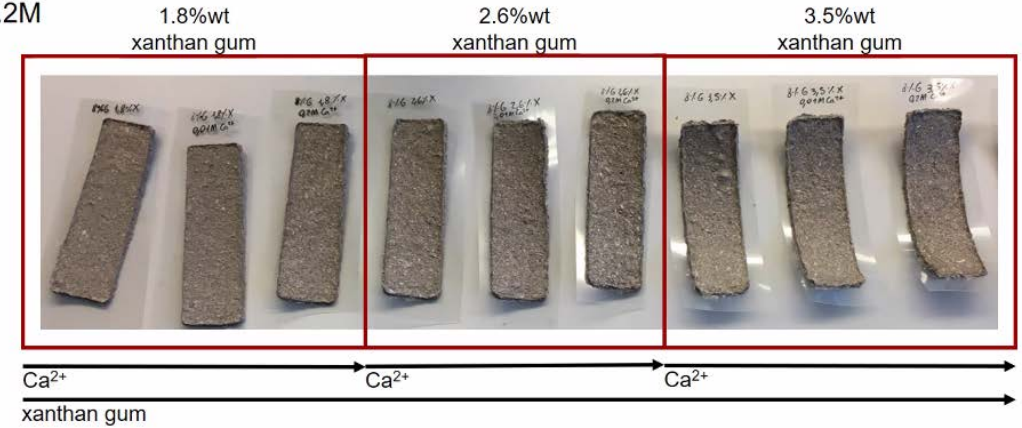
METHOD DEVELOPMENT:MATERIAL VARIATION OF GLYCEROL/WATER

Addition of Ca^{2+} inside the mixture

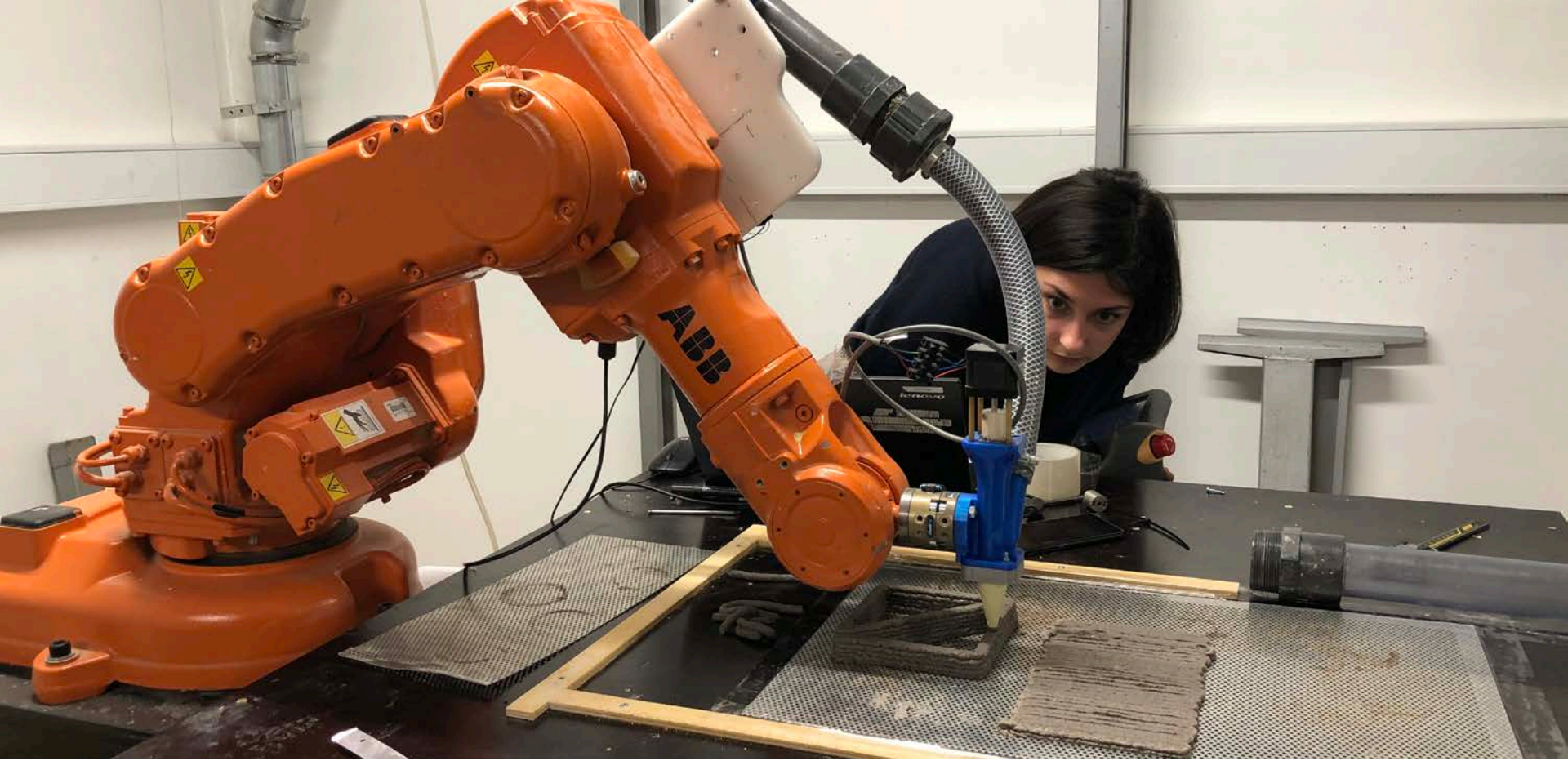
→Addition of aqueous solution $CaCl_2$:

→0.01M

→0.2M



INTRODUCING NEW COMPONENTS



METHOD DEVELOPMENT:FABRICATION

Camera

3D Imaging/Lidar

Material Humidity

Evaporation

Environment

+ Machine Learning

Intel Realsense

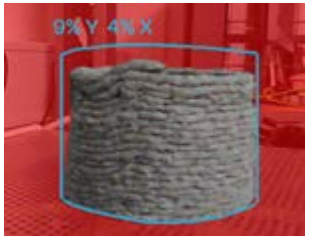
Thermal Sensor

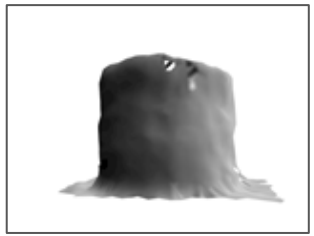
relative humidity

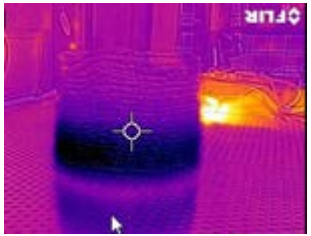
Probe

FLIR Le

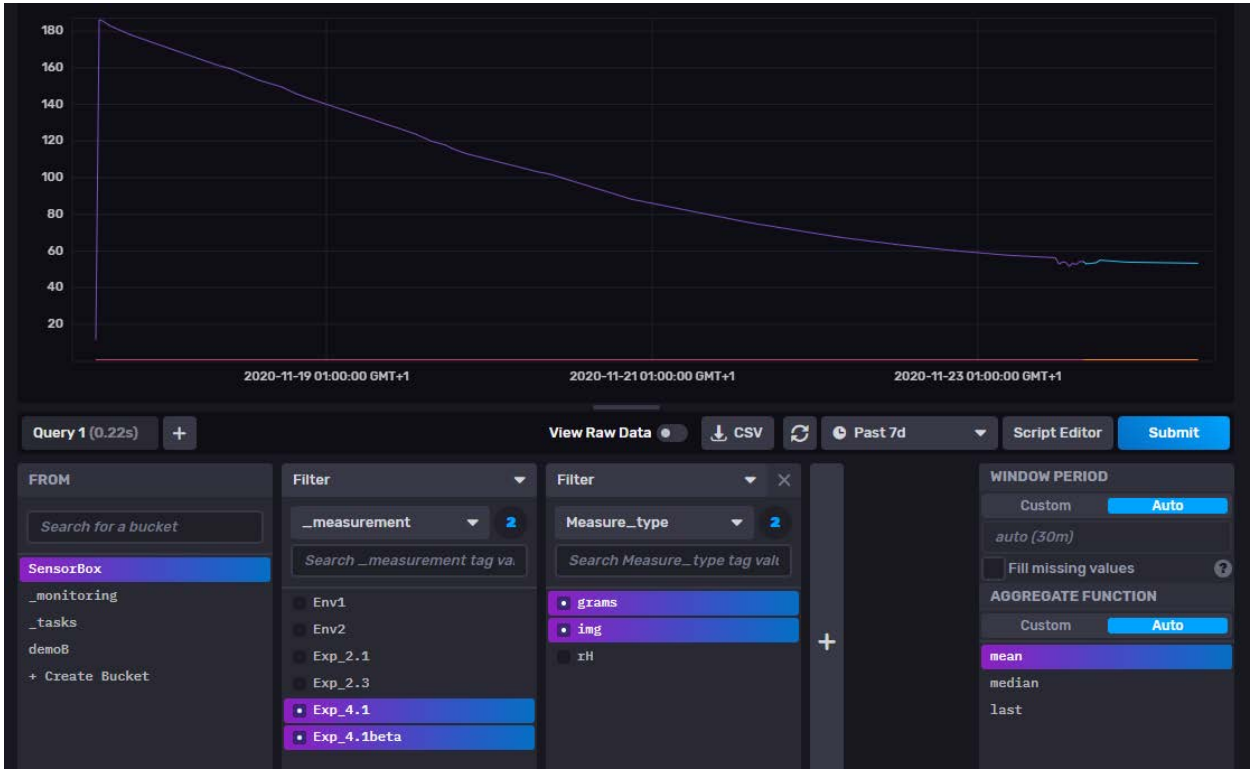
Temperature

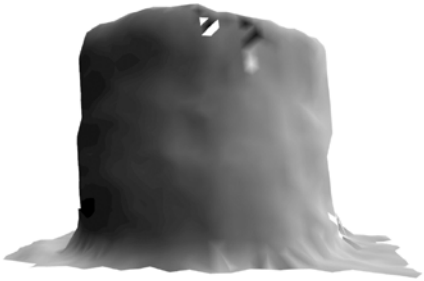


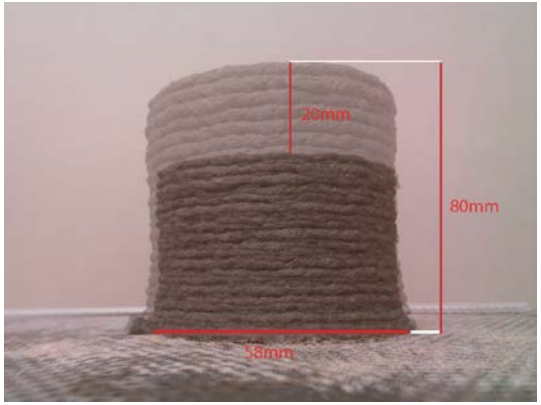


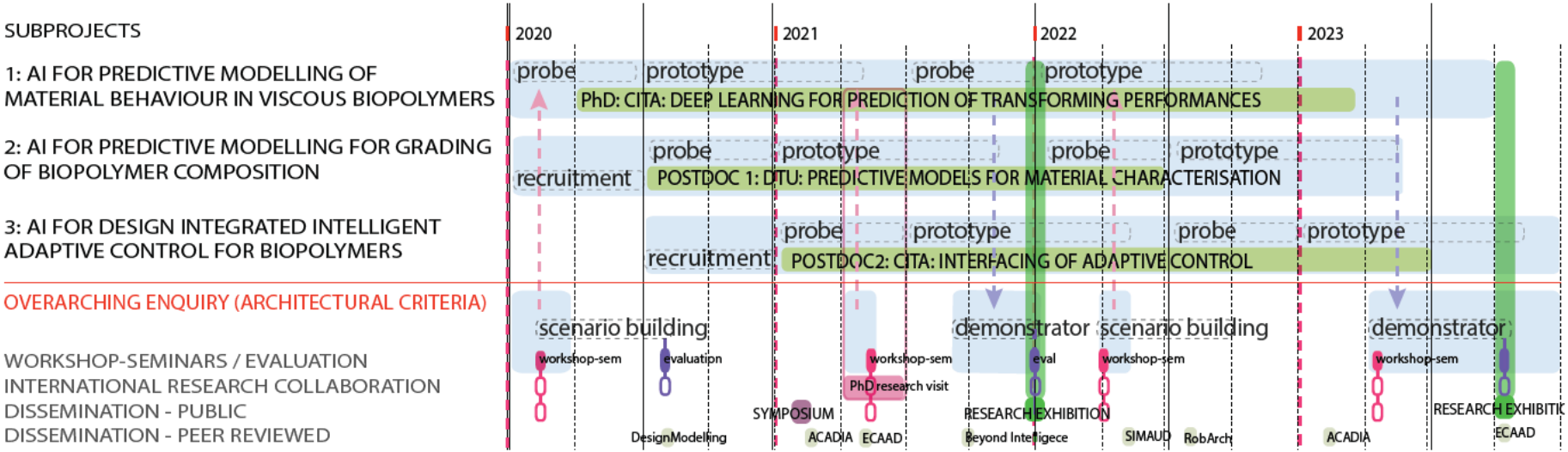


METHOD DEVELOPMENT:BUILDING A 'SENSOR BOX'







INITIAL FINDINGS

Trajectories