ULTRAFAST 3D PRINTING WITH INTERNAL STIFFNESS CONTROL

"Come build your own next-gen 3D printer"

MOTIVATION

Tissue engineering is key to reducing healthcare cost and to alleviating the under-supply of human organs. Currently, it is estimated that ca. $2.5 billion and 10-12 years are needed to develop one clinically applicable drug. This cost can be curbed by engineering tissues for more efficient pre-clinical drug screening. Meanwhile, there is an utter mismatch between the clinical demand and the supply of human organs. More than 100,000 patients in the world are waiting to receive donation. The main sources remain from deceased donors – whole organ fabrication will be required in the future. Vascularization is essential to tissue and organ viability. Our ultimate goal is to reverse computed tomography (CT) in light-assisted 3D printing to enable ultrafast bioprinting of fully vascularized artificial tissues.

RESEARCH DIRECTIONS

You are encouraged to contact us early (yyan@dtu.dk) to discuss your research interest and academic background. A concrete scientific question and associated research objectives will be laid out according to the outcome of such discussions. In general, this interdisciplinary project operates at the convergence of at least three research lines:

Opto-mechanical engineering: you will have the chance to design and test optical setups that minimize beam étendue and optimize printing resolution/fidelity. Emphasis is put on experimental skills – candidates with mechanical engineering background and/or enjoys DIYing new machine-tools are most welcome to contact us.

Polymer chemistry: you will have the chance to synthesize new photopolymers or test new precursor recipes that are optimized for the new 3D printing strategy. Alternatively, you may choose to test the biocompatibility of existing polymer resins and evaluate their applicability in engineering artificial tissues. Candidates with a background in chemistry will be favored.

Computer sciences: you will have the chance to improve the current, Radon transform-based algorithm for pattern sequence computation. Such improvement will lead to greater geometric fidelity of the workpiece and a better control over surface smoothness. Alternatively, you may investigate the conversion between CAD format and grayscale volume data or choose to design an inline monitoring system that provides real time feedback to sequence control.

PROJECT OPTIONS

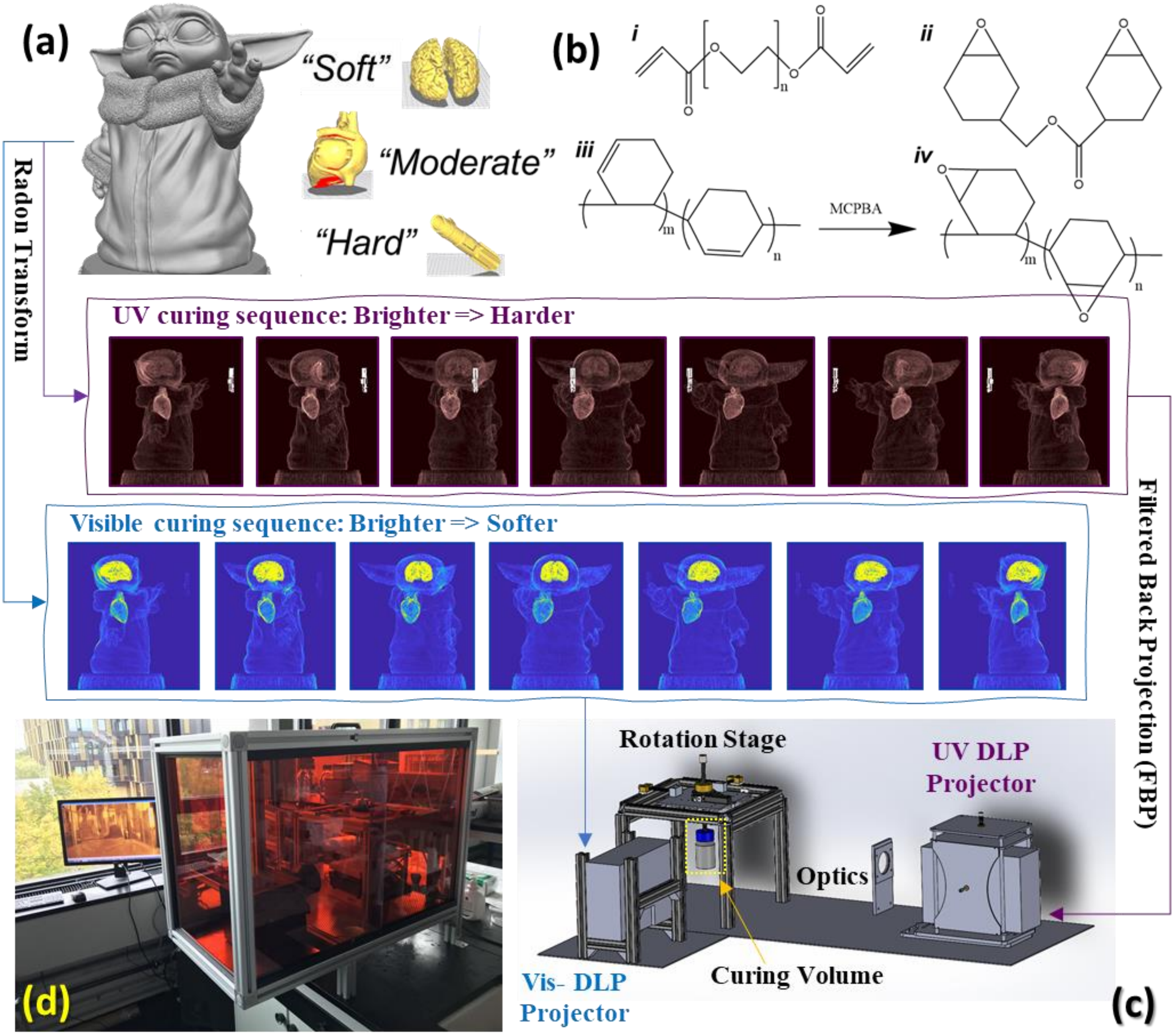
M.Sc./B.Sc. Projects at DTU Kemi, in collaboration with DTU Mekanik and DTU Compute

FURTHER READING

Loterie, D.; Delrot, P.; Moser, C., High-resolution tomographic volumetric additive manufacturing. *Nature Communications* **2020,** *11* (1), 852.

Kelly, B. E.; Bhattacharya, I.; Heidari, H.; Shusteff, M.; Spadaccini, C. M.; Taylor, H. K., Volumetric additive manufacturing via tomographic reconstruction. *Science* **2019,** *363* (6431), 1075.

PROJECT ILLUSTRATION



(**a**) A multiscale structure with internal property variations can be 3D-printed in one shot by exploiting a synergy between reversed tomography and wavelength-sensitive photopolymer. Tomographic vat photopolymerization (TVP) allows the specification of light dose ratio for each point of an object by computing independent curing pattern sequences for various wavelengths. (**b**) Chemical structures to be used in the photopolymerization: *i*. PEGDA – Polyethyleneglycol Diacrylate; *ii*. EEC – 3,4-epoxycyclohexylmethyl 3,4-epoxy-cyclohexanecarboxylate; *iii* & *iv*. PCHD - poly(cyclohexadiene) - is a mixture of 1,4 and 1,2 addition. The synthesis allows for substantial variation between the two types of addition. The peroxidation reaction is expected to have a yield of more than 90% but one can choose to only partially epoxidize the PCHD. (**c**) A TVP setup with two light sources. Each source builds a 3D dose distribution in the curing volume independently, which dictates the printout shape. Two distributions can be superposed upon the same building volume to define the relative light intensity voxel-by-voxel. (**d**) A photo of the prototype machine-tool, currently set up in B207 R255.