



Project Proposal for Ph.D.

Project Details (The research problem must clearly indicate the need for an interdisciplinary approach)

Project Title

Bayesian Active Learning for Experimental Discovery of Auxetic Lattice Geometries: Building a Property Map from Real Specimens

Project Summary

(Minimum 500 and maximum 2000 characters)

Every current machine-learning approach for designing auxetic lattices — structures that exhibit a negative Poisson’s ratio and uniquely expand laterally when stretched — relies on a large pre-generated database of finite element simulations. This creates a fundamental problem: simulated databases are expensive (thousands of CPU hours), reflect the modeller’s geometric assumptions rather than the true design landscape, and critically, never capture the manufacturing variability introduced by additive manufacturing (AM). Real printed specimens routinely deviate from nominal designs by 50–150 μm in strut dimensions, and these deviations alter mechanical properties by 10–20%. This interdisciplinary project proposes the first active learning framework for auxetic lattice design driven entirely by real experimental data. The concept is fundamentally different from existing work: instead of generating a database upfront and learning from it, a Gaussian Process (GP) surrogate is seeded with a few physically tested specimens, then uses a Bayesian acquisition function (Expected Improvement or Upper Confidence Bound) to decide which geometry to fabricate and test next — prioritising regions of the design space where the model is most uncertain. This iterative loop converges on an accurate property map of the true (AM-inclusive) geometry–property relationship using a few hundred specimens, compared to the thousands of simulations typically required. The active learning algorithm and GP surrogate must be tightly coupled to a real AM fabrication and testing pipeline. Upon convergence, an inverse design pass identifies geometries meeting prescribed property envelopes (e.g., stiffness 0.3–0.5 GPa AND NPR -0.4 to -0.2 AND specific energy absorption >5 kJ/kg simultaneously). The framework is validated by demonstrating that it requires significantly fewer experimental evaluations than random sampling or grid search to achieve the same surrogate accuracy, and by testing the inverse-recommended designs against their predicted properties.

Ph.D. Supervisors*
(Supervisor 1 and Supervisor 2 cannot be from the same department of IITD)

Role	Name of Faculty	Academic Unit in IITD/Institute/University	Email ID (Official)
Supervisor 1*	Dr. Kusum Meena	Department of Mechanical Engineering, IIT Delhi	kmeena@mech.iitd.ac.in
Supervisor 2	Prof. Souvik Chakraborty	Department of Applied Mechanics, IIT Delhi	souvik@am.iitd.ac.in

*Supervisor 1 must be from IIT, Delhi.
+All cells in this table are mandatory fields that need to be filled by faculty for consideration of proposal.
\$The date of superannuation of supervisors should be at least three years from the date of registration of selected candidates.

Project requirements (Student qualifications, experience required, etc)
*The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)

- B.Tech / M.Tech / M.E. in Mechanical Engineering, Materials Science, or related discipline with strong academic record (CGPA $\geq$ 7.5 or equivalent).
- Hands-on experience or strong interest in additive manufacturing (FDM preferred) and mechanical testing; candidates who have operated a UTM or 3D printer in a lab setting will be preferred.
- Basic programming competency in Python; willingness to learn Gaussian Process modelling (GPy, scikit-learn, BoTorch) and experimental design methods.
- Strong experimental aptitude and attention to detail.
- Concepts (Latin Hypercube Sampling, factorial design) is advantageous.
- Candidates with combined interest in experiments AND computation (rather than purely one or the other) are ideal for this project given its iterative experimental-computational loop.

Source of fellowship/funding and project number
(CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)

Institute

Role of Faculty Members involved:

Supervisor-1	Supervisor 1 (Dr. Kusum Meena) will lead the experimental components: design and parameterisation of the auxetic unit cell design space, fabrication batch planning and quality control, mechanical testing programme (UTM + DIC), experimental data curation and geometric characterisation (micro-CT / optical).
Supervisor-2	Supervisor 2 (Prof. Souvik Chakraborty) will lead the computational components: Gaussian Process surrogate modelling, active learning loop design, inverse design algorithm, and benchmarking against passive sampling strategies. He will co-supervise the student on statistical methodology.

- Note :-**
1. Approval from the respective DRC/CRC/ScRC of your Department/Centre/School will be required for using the "Full-time Institute Assistantship (Category-wise) (FIA)" for selecting the students in SRe.
 2. Declaration:- Faculty members, please ensure that you have at least 3 years of service left before superannuation along with adequate sitting space & lab facilities for the SRe student.
 3. PI/s are also encouraged to submit joint proposals with AIIMS, NII, JNU and institutes with which IITD has an existing MoU. If the Co-PI (Supervisor 2) is from outside IITD, kindly share his/her detailed CV.
 4. If a research scholar is to be considered for selection under the project fellowship, then the project should have a minimum of two-year duration remaining.
 5. A candidate applying with a valid JRF/INSPIRE/any national level fellowship should have at least two-year validity from the date of joining the Ph.D. program.
 6. The third supervisor's name (if required) can be added only after the formation of Student Research Committee (SRC) subject to a strong recommendation of SRC and subsequent approval from the competent authority.
 7. If Institute fellowship is being sought, then DRC approval of the parent department of Supervisor 1 is required at the time of selection.