

Gathering25

Realising vision, advancing automation

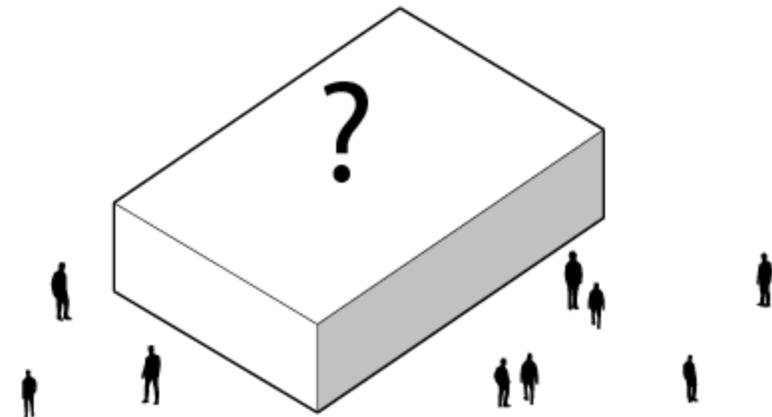
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GPT-BIM enabled generative design for cleanrooms.

Executive Summary

- Introduction, Context & Problem.
- Why it matters ?
- Aim of the study.
- Experimental Research Process Framework.
- Research Methodology
- Evaluation of Data –Industry Expert Analysis.
- Technical & Ethical Barriers
- Research Findings



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Introduction

- Cleanrooms: controlled environments with strict contamination and regulatory demands (ISO 14644).

Problem

- Spatial planning is complex and slow; research hasn't combined GPT models with generative design for cleanrooms.
- Relatively new and unexplored area of research.
- Addressing architectural challenges in cleanroom design.

Context

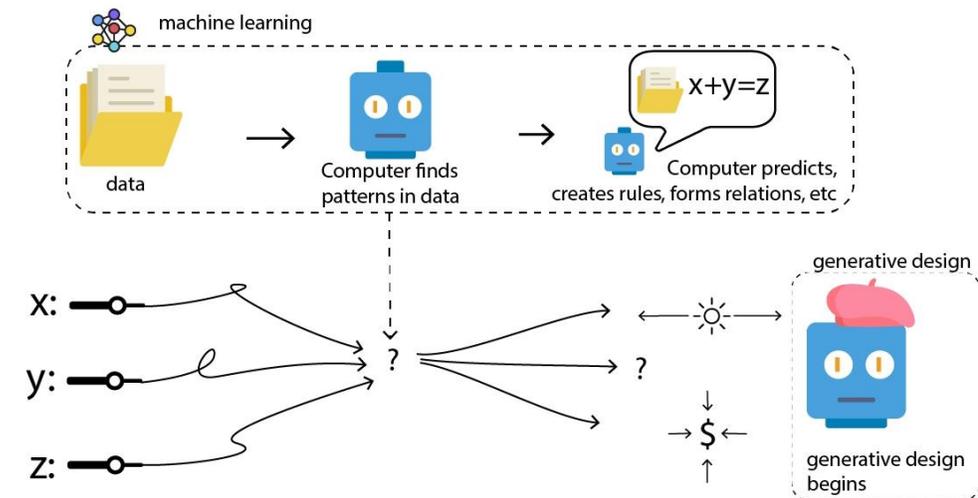
- Irish Economic landscape [Pharma / Semi-conductors / Medtech manufacturing]



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Why it matters ?

- Current design methodologies and processes are labour intensive and unstructured.
- Industry demands [Pharma / Semi-conductors] speed to demand pressures.
- Convergence of technologies : Opportunity to integrate latest ML technologies with BIM technologies.
- Automate repetitive tasks, accelerate concept design, enhance collaboration/quality.



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Aim of this Study

The thesis investigates how GPT models can be integrated with BIM-based generative design to automate early-stage spatial planning of cleanrooms and evaluates this via expert interviews and a real project benchmark.

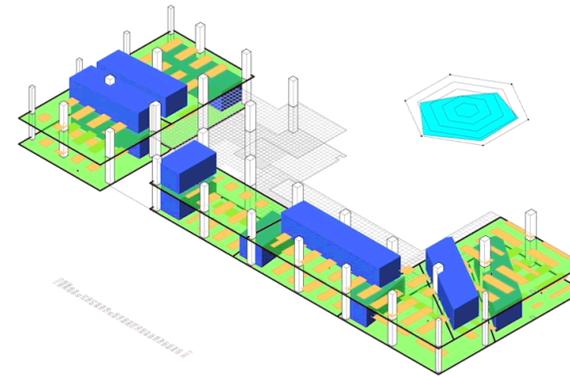
What is GPT ?

Generative pre-trained Transformers – Part of Natural Language Processing (NLP)

- Also known as LLMs Large Language Models



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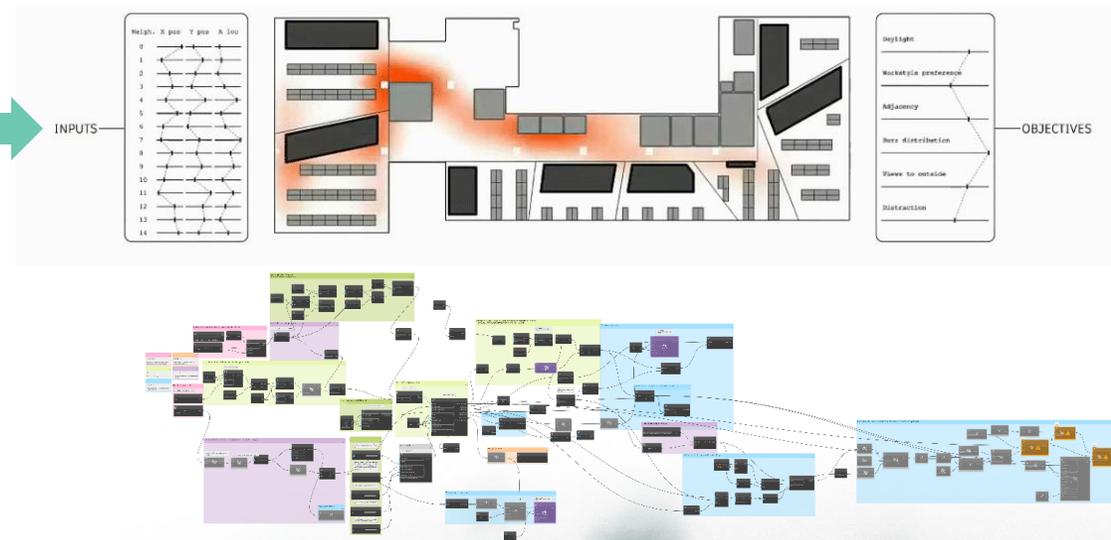
What is Generative Design ?

In a nutshell, generative design is a goal-driven approach to design that leverages automation so that designers can:

- Have better insight into their designs;
- Make faster, more informed design decisions; and
- Explore more options using the power of computers.

Experimental Research Process Framework

4-Step Pipeline



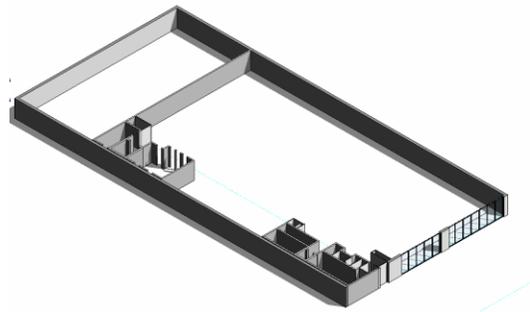
- Extract data from client's URS / EIR / TGD /ISO documents using Prompt Engineering.
- Convert data into CSV file.
- Set design boundary & constraints in Revit
- Import CSV file into Dynamo Script
- Revit GD :randomization & optimization / MOGA for option filtering

MOGA : multi-objective genetic algorithm



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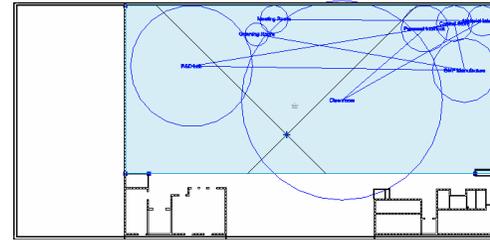
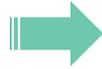
Experimental Research Process Framework



Sheet 2: Architectural Room Data (Room Book)
This sheet extracts data from the "Area programme EHV 2" (Attachment A1.02) and related drawings. A sample table might be:

Room No.	Designation	Area (m ²)	Room Height (m)	D/E Pressure (Pa)	Climate Zone	Lighting (Lux/K)	Floor System	Comment
111	Classroom ISO 5	168	3.0	+37.5	G	870 / 4000K	Forbo Coco Rex S2 grid 600x600/1200x1200; 50mm (T&O)	Main production area
112	Personal Lock ISO 7	13	3.0	+12.5	G	870 / 4000K	Teardrop/Integrated	Entry area for personnel
113	Personal Lock ISO 5	10	3.0	+25	G	870 / 4000K	Teardrop/Integrated	Higher pressure lock
114	Material Lock ISO 7	2	3.0	+12.5	G	870 / 4000K	Teardrop/Integrated	Compact area
115	Material Lock ISO 5	2	3.0	+25	G	870 / 4000K	Teardrop/Integrated	Compact area, higher pressure
Total		195						

The "Climate Zone" column uses the codes provided in the document (e.g. "G" for a specific zone). You can add further columns if needed (e.g. "Permanent Workplaces", "Air Change Rate", etc.).



Phase 1 of framework.

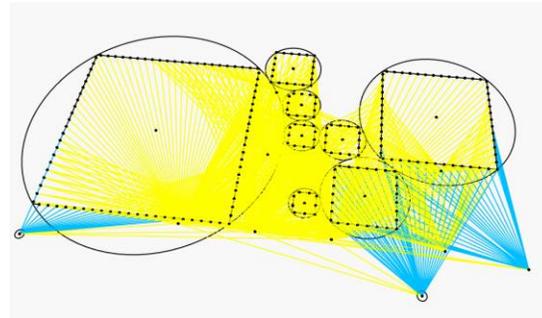
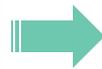
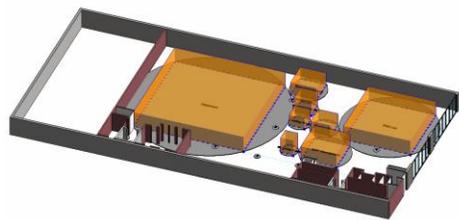


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Research Methodology

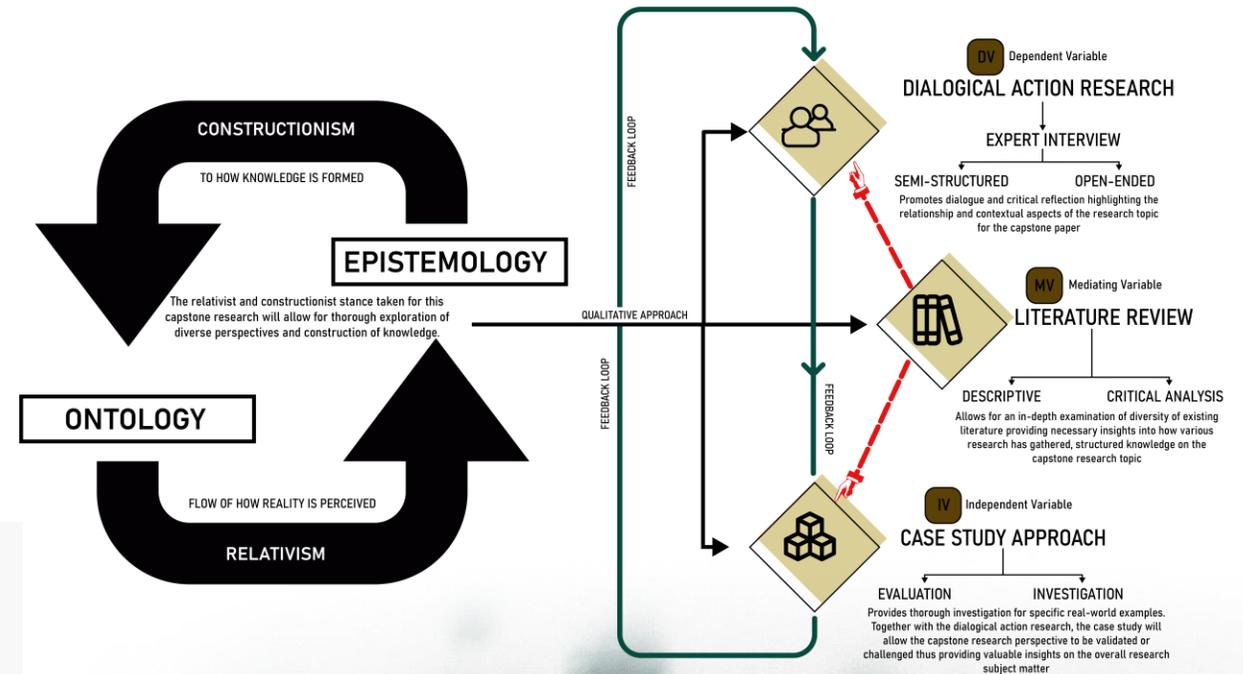
- Dialogical Action Research
- Semi-Structured Interview Process-Two rounds of interviews.
- Reflection process –mutual understanding and identifying core issues from both practical and theoretical standpoint.
- Improvements to the process framework.



Phase 2



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Evaluation of Data-Expert's Analysis

Key Themes:

- Framework provided a digital transformation of the early design phase.
- Conversion of data from URS/EIR and TGD's into a digital and interactive data set and integration into Dynamo improves data analysis
- Shift from traditional process driven design into a multi-collaboration approach.
- Allows for automation of labor-intensive processes.
- Workflow for the translation of massive document data datasets into actionable spatial layout design and enables real time parametric driven design iterations.

Expert	Industry	Exp (years)	Knowledge of GPT Models	Technical Barriers	Benefits to Industry	Legal & Ethical Issues	Benefits to Decision Making
1	Architecture	5-6	None	Limitation of the dynamo script in factoring 3-dimensional element. No consideration from the TGD docs.	✓	✗	✓
2	Pharmaceutical /Cleanroom End-user	13-14	Limited	Relevant URS data.	✓	✗*	✓
3	Architecture	6-7	Limited	Restrictive design. Accuracy of output data.	✓	✓	✓
4	Process Engineer / Cleanroom Designer	17	Extensive	Customer hesitancy / lack of knowledge / IP*	✓	✓	✓
5	Process Engineer / Cleanroom Designer	30	Average	Data availability for LLM training / QA & QC by human element.	✓	✓	✓
6	Semiconductor Cleanroom Designer	32	None	Data availability for LLM training/ IP*	✓	✓	✓



Technical & Ethical Barriers

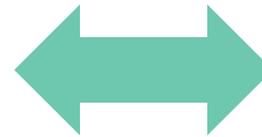
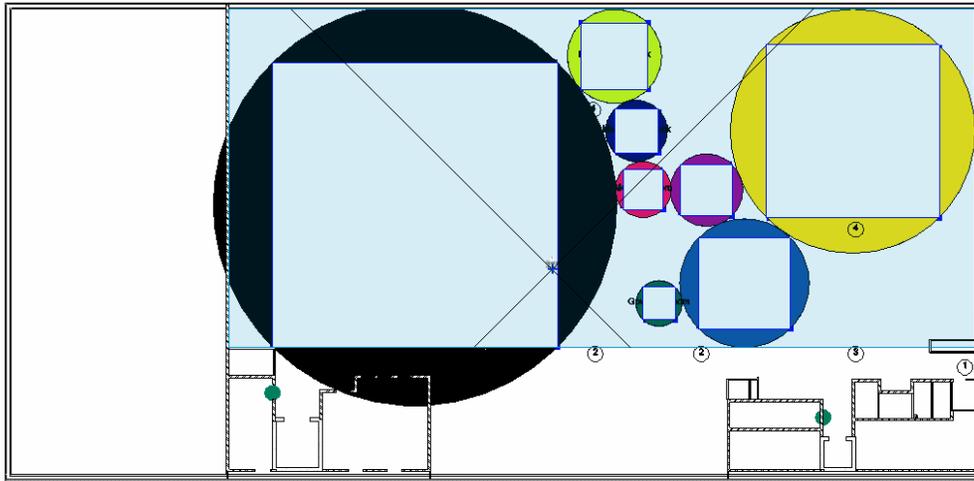
- Data Privacy
- Intellectual Property rights
- Design Copyright
- Design reliability

- Unstructured/ fragmented nature of the AEC industry
- Stringent guidelines by the construction or architectural governing bodies.
- AEC slow adoption of innovation.
- Lack of clean dataset to train domain specific GPT models.



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Research Findings



Experimental Framework

Case Study Project



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 Thank you / Q&A