# Final Project Ideas

This is a collection of starting points for ideas for your Final Project. There are two for each level 6 module.

Scroll through, or use the navigation bar within your pdf viewer to jump quickly to modules and project briefs you might be interested in.

You need to choose one of the following ideas and use it as the starting point for your project proposal – which will still need to be written and submitted by yourself as part of your assessment for the Final Project module.

# CM3045 3D Graphics and Animation

## Project Idea Title 1: Physics based Game

### What problem is this project solving?
Create a 3D game that uses physics as a key element of gameplay.

### What is the background and context to the question above in 150 words or less?
Physics simulation is one of the most powerful ways of creating compelling gameplay that feels real, going back to classic games like Half-life and angry birds. Physics based games are fun, dynamic and unpredictable and allow for very rich interaction. This project should draw on both the 3D Graphics and Animation and the Game Development modules to create a short but compelling game

### List some recommended sources for students to begin their research
- Surgeon Simulator (https://www.surgeonclassic.com/)
- Human Fall Flat (https://www.nobrakesgames.com/humanfallflat)
- Garry's Mod (https://store.steampowered.com/app/4000/Garrys_Mod/)
- Free Physics games on itch.io (https://itch.io/games/free/tag-physics/tag-sandbox)
- Katamari Damacy Reroll (https://en.bandainamcoent.eu/katamari/katamari-damacy-reroll)

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final product will be a fully functional video game that uses physics to create a fun, easy to play experience.

The gameplay should be a **maximum** of 5 minutes.  Shorter and more polished is preferable and will receive higher marks than longer and not as well executed.

It will have the following game design characteristics:

- Easy to pick up and play
- Uses physics simulation as a key element of gameplay
- Instantly fun and gratifying
- May optionally use other elements of the 3D Graphics and Animation course, such as keyframe animation and shaders, to enhance the effect.
- 3rd party assets may be used for graphics, animation and audio, but you must have permission and credit them appropriately

### What would a prototype look like?
*(What would it show? What does it need to prove? What **IS** important to make clear? What is **NOT** important at this stage?)*

Prototype needs to show a core physics-based gameplay loop which is challenging, engaging, simple to pick up but which shows strong promise for emergent complexity. It needs to prove you know what the core of your game is, what the player is meant to be doing and how they are going to do it.

Most mechanics and broad aspects of level design should be clear at prototype stage. Graphics and sound are not important at this stage. Prototype is perfectly fine using boxes and other primitive objects.

## What kinds of techniques/processes are relevant to this project?

- Iterative development
- Frequent playtesting
- Unity/C#.
- 3D scene design
- Unity Physics Engine

## What would the output of these techniques/processes look like?

- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from play testers.
- Some aspects of the game have been dropped from the first iterations, some have been added, some have been modified, in line with AGILE development practices.
- Several sets of feedback from players that inform your ongoing development and design process.

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)? What criteria are important?

Student will use play testers and solicit feedback on the developing game. Main source of data will be player opinions and, where possible, player actions where it's possible to directly observe playtesting.

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?

- Game can be loaded, started and finished without major bugs/crashes.
- The game makes use of Unity's physics engine
- Poor audio-visual presentation.
- Gameplay is confusing and/or boring.
- Written report lacks research, detail of process, issues encountered in production, and/or doesn't name influences or audio-visual assets used appropriately.

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?

- Game functions well without bugs.
- The gameplay makes good use of physics to create a fun and dynamic experience
- Good audio-visual presentation, possibly using keyframe animation and/or shaders
- Gameplay is quickly understandable, it's easy to start playing.
- Written report makes clear the challenges faced and how they were overcome. Makes clear the influences that went into the game (e.g. games played and analysed, which mechanics were inspired from where etc.).

- Audio-visual assets appropriately credited.
- Playtesting feedback is clearly gathered and acted on.


## For this brief, what would an **outstanding** (e.g. 1st) student project look like?

- Game is highly-polished technically, and in terms of audio-visual presentation.
- Game uses innovative and original physics-based mechanics (or well-known mechanics in a novel manner)
- Possibly also using advanced animation and shader techniques
- Game requires no instructions – it's very clear what the objective is and how to achieve it from the opening screen.
- Game is easy to start playing, but repeated play shows a well-selected set of simple mechanics that lead to depth and emergent complexity as the player replays the game over several sessions.
- Written report has excellent and concise writing style. Research and influences behind the project are clear and detailed, with extensive analysis of background works.
- Playtesting has been frequent/ongoing, extensive feedback has been gathered and documented and it's very clear how this has been incorporated into the iterative development of the game.
- It is evident there have been several version/iterations of the game, and the challenges at each point have been documented and analysed.

# Project Idea Title 2: Visual Effects for a short film

## What problem is this project solving?
Use GPU shader techniques to create a distinctive visual style for a short animated film developed in Unity.

## What is the background and context to the question above in 150 words or less?
The graphical quality of real time game engines like Unity has increased dramatically, making it possible to create entire animated movies in real time that would only have been possible in the past using long, offline rendering techniques. Modern GPU programming techniques can create a very wide range of visual styles from highly realistic through gritty cyberpunk to brightly coloured cartoon styles. In particular, lighting can add a lot of style to a scene or film. The aim of this project will be to use animation and shader programming to create a short film with a particular style.

## List some recommended sources for students to begin their research
- A good starting point is to watch some animated, visual effects-based or even live action films to get an idea of the style you would like to capture
- Alan Zucconi's tutorials are an excellent way to learn about shader programming techniques
- The GPU Gems book series is a little bit old now, but still contains a lot of very valuable techniques that you can easily implement
- The ACM SIGGRAPH and GDC conference proceedings are an excellent source of cutting edge techniques

## What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final product will be Unity build/project that plays back a short film when run. It should use GPU shaders to create a distinctive style. It does not have to be interactive. A video of the film should also be included

The film should be a **maximum** of 3 minutes. . Shorter and more polished is preferable and will receive higher marks than longer and not as well executed.

It will have the following features:

- It should use keyframe animation (and/or possibly physics or particle systems) to create an animation
- It should contain GPU shaders applied to particular objects to create visual effects
- It should include suitable lighting that compliments the style
- It will take the form of a technical show reel, focused on graphics. It does not need to have a narrative and will not be marked on things like story.
- 3rd party assets may be used for graphics, animation and audio, but you must have permission and credit them appropriately

## What would a prototype look like?

*(What would it show? What does it need to prove? What **IS** important to make clear? What is **NOT** important at this stage?)*

Prototype needs to show at least one of the key shader techniques you will be used. It can be applied to simple objects, not the final scene.

## What kinds of techniques/processes are relevant to this project?

- Iterative development
- Unity/C#.
- 3D scene design
- Keyframe Animation
- GPU Shader programming

## What would the output of these techniques/processes look like?

- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from play testers.
- The scene and visual style are gradually built up by adding more elements and shaders over time, while always having a working prototype.
- Feedback is solicited from viewers to improve the film

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)? What criteria are important?

The graphics techniques can be evaluated both in terms of quality and performance. Performance can be measured in terms of frame rates, and changes in frame rates when adding different features.

Quality is a bit more subjective. In part quality can be demonstrated by showing screen shots of the film or a video of the whole animation. However, it is also important to measure viewer response. This can be done by showing viewers two still images or videos, one with and the other without a particular graphical features and asking them to judge which they prefer.

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?

- The film can be loaded, started and finished without major bugs/crashes.
- The game makes use of GPU shaders and Unity's lighting and animation techniques
- The visual output is of poor quality and/or does not come together into a coherent style
- Written report lacks research, detail of process, issues encountered in production, and/or doesn't name influences or audio-visual assets used appropriately.

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?

- Film runs well without bugs.

- The gameplay makes good use of moderately complex GPU shaders, animation and lighting techniques to create a coherent visual style
- The graphical style if of good quality
- Written report makes clear the challenges faced and how they were overcome. Makes clear the influences and techniques that went into the film
- Audio-visual assets appropriately credited.
- viewer feedback is clearly gathered, well presented and acted on.

For this brief, what would an **outstanding** (e.g. 1st) student project look like?
- Film is highly-polished technically, and in terms of Graphical presentation.
- It makes use of very advanced, or original GPU shader, animation and lighting techniques
- The graphical quality is approach or reaching professional standards
- Written report has excellent and concise writing style. Research and influences behind the project are clear and detailed, with extensive analysis of background works.
- Extensive viewer feedback has been gathered and documented and it's very clear how this has been incorporated into the iterative development of the film.

# CM3035 Advanced Web Development

## Project Idea Title 1: A non-profit web application

### What problem is this project solving?
You should build a web application that can help users tackle or solve a socially useful problem in the non-profit sector.

### What is the background and context to the question above in 150 words or less?
A large number of web applications are built for primarily for commercial reasons, to sell products to people. These include stores such as Amazon, Etsy and Ebay. One area of application development that is often under-served are non-commercial applications. Often times non-commercial applications do not attract funding. It is your job to identify a social problem that could be address by a web application and to build that web application. Such an applications may be designed to help a charity or governmental or address some other social issue.

### List some recommended sources for students to begin their research
- **THE NHS app** https://www.nhs.uk/nhs-app/
  - This application allows citizens of the UK to access their medical records and access real-time medical advice
- **Bit Warden Free edition.** https://bitwarden.com/
  - Allows users to store their computer passwords safely in the cloud so they can access their passwords anywhere
- **They Work For You** https://www.theyworkforyou.com/
  - Allows citizens of the UK to view and follow the daily activity of the British Parliament and allows citizens to monitor the voting records of MPs and Ministers
- **Share The Meal** https://sharethemeal.org/en/
  - Application allows users to donate funds towards ending hunger around the world
- **The HTTPS Everywhere/SSL Observatory** https://www.eff.org/https-everywhere & https://www.eff.org/observatory
  HTTPS Everywhere is a browser plugin that ensures users always use HTTPS where possible on the internet. Additionally the SSL Observatory is a database that allows users to check if SSL/HTTPS security certificates and authorities are valid.

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final product would be a working web application. Which solves the problem stated by the student. It would be implemented using an appropriate web framework (i.e. Django, Rails, Flask, GWT ) and make correct use of an appropriate data store (postgresql, mysql, redis, etc…).

The web application code should be clean and easy to understand. The logic of how is solved the problem should be easy to follow. The use of the data store should be appropriate for the problem at hand. For instance, if using a relational database the data store should be correctly normalised.

It should be easy to run the web application and interact with it. An appropriate web application client must be provided to interacting with the server side portion of the application . Typically this will be a series of web pages. There are other appropriate clients such as a mobile application.

## What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A working web application with an appropriate and working client side interface. The client side interface should be clear and easy to use and it should be clear for users how to interact with the application. The client side interface does not have to be professionally designed.

What is important will depend on the focus of the application. An application serving a Disabled community should include appropriate accessibility measure and design for the users. At prototype stage accessible design may not be appropiate for other application types.

A server-side application intended to be accessed mainly programmatically MUST include an appropriate API. Such as a server side application that is connected to via an mobile application. Such an API would usually be a REST API.

## What kinds of techniques/processes are relevant to this project?
Use **short** bullet points

- Server side programming (e.g Django/python, Rails/ruby, Tomcat/Java, etc...)

- Frontend programming (javascript)

- API design (REST standards)

- Data store design/implementation (normalisation etc…)

- unit testing

## What would the output of these techniques/processes look like?
Use **short** bullet points for each technique/process named.

- Server side: a clearly designed backend application that implements the application with minimal code and has good test coverage

- Frontend programming. An appropriate client for the web application that lets users use the web applications

- API Design: A well designed and unit tested API that covers all necessary functionality for the web applications

- Data Store: A correctly install and configured data store such as a relational database and the data store is appropriately designed for the task

How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?

What criteria are important?

The student should use appropriate white and black box testing. The application should have appropriate unit testing. Students should also use user testing to get feedback on their application and use that feedback to improve the application or inform the design

For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?

Use **short** bullet points…

- Application can be easily loaded and is free of application breaking bugs
- Design across the application is rudimentary but functional
- Design of client side is functional but unclear.
- Report details the application functionality but lacks any engagement with prior art, research, literature and does not evidence any engagement with the wider web development world

For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

Use **short** bullet points…

- Application functions well with no obvious bugs
- The main functionality of the application is covered with appropriate unit tests
- The client side is easily understandable and easy to use
- The report gives a clear account of how the application was designed included the literature, research and prior-art that informed the design of the application
- User testing was appropriately gathered and has been used to inform the design of the application.
- Report is written to a good standard of english

For this brief, what would an **outstanding** (e.g. 1st) student project look like?

Use short bullet points…

- All areas of the application (front end, unit testing, data store/model, etc…) are implemented to a highly polished standard
- Client side interface is clear and usable to an exemplary standard
- Minimal bugs are present in the code
- Unit testing exhaustively covers the application's functionality, all student code and tests all possible failure modes
- Extensive user testing that has informed the design of the application at all stages
- Report is written to an excellent standard, with detailed information on the literature, resaerch and prior-art that informed the project
- The report is highly detailed with extensive self-reflection about the design and implementation processs
- The report reflects clearly on what has worked well and what has not and provides insight in to future directions.

## Project Idea Title 2: A Collaboration web application

### What problem is this project solving?
Build an application that helps people collaborate more effectively

### What is the background and context to the question above in 150 words or less?
Humans need to collaborate in all aspects of their lives, from work to schools to hobbies. In this project you need to find an aspect of collaboration that could be served with an appropriate web application. This may range from enabling scheduling to collaborating simultaneously on a piece of work. In this project you're tasked with building a web application whose main focus is to enable collaboration between a group of people.

### List some recommended sources for students to begin their research
- **Trello** https://trello.com/en-GB
  A productivity application for teams built around a series of communally readable and editable boards that can be used to track and assign tasks and work
- **Github** https://github.com/
  Cloud based code repository for the git source control application. This allows teams to share computer code. The website includes extensive tools for project managing software development in a team
- **Doodle** https://doodle.com/en/
  A simple application that lets groups of people collaborate to pick the dates for meetings and events.
- **Etherpad** https://etherpad.org/
  A system for groups of people to collaboratively edit text documents.
- **Sharepoint** https://www.microsoft.com/en-gb/microsoft-365/sharepoint/collaboration
  A document management and storage system that integrates with Microsoft Office products. This allows teams of people to easily share documents and other computer files

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final product would be a working web application. Which solves the problem stated by the student. It would be implemented using an appropriate web framework (i.e. Django, Rails, Flask, GWT ) and make correct use of an appropriate data store (postgresql, mysql, redis, etc…).

The web application code should be clean and easy to understand. The logic of how is solved the problem should be easy to follow. The use of the data store should be appropriate for the problem at hand. For instance, if using a relational database the data store should be correctly normalised.

It should be easy to run the web application and interact with it. An appropriate web application client must be provided to interacting with the server side portion of the application . Typically this will be a series of web pages. There are other appropriate clients such as a mobile application.

## What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A working web application with an appropriate and working client side interface. The client side interface should be clear and easy to use and it should be clear for users how to interact with the application. The client side interface does not have to be professionally designed.

What is important will depend on the focus of the application. An application serving a Disabled community should include appropriate accessibility measure and design for the users. At prototype stage accessible design may not be necessary for other application types.

A server-side application intended to be accessed mainly programmatically MUST include an appropriate API. Such as a server side application that is connected to via an mobile application. Such an API would usually be a REST API.

## What kinds of techniques/processes are relevant to this project?

Use **short** bullet points

- Server side programming (e.g Django/python, Rails/ruby, Tomcat/Java, etc...)

- Frontend programming (javascript)

- API design (REST standards)

- Data store design/implementation (normalisation etc…)

- unit testing

## What would the output of these techniques/processes look like?

Use **short** bullet points for each technique/process named.

- Server side: a clearly designed backend application that implements the application with minimal code and has good test coverage

- Frontend programming. An appropriate client for the web application that lets users use the web applications

- API Design: A well designed and unit tested API that covers all necessary functionality for the web applications

- Data Store: A correctly install and configured data store such as a relational database and the data store is appropriately designed for the task

How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?

What criteria are important?

The student should use appropriate white and black box testing. The application should have appropriate unit testing.  Students should also use user testing to get feedback on their application and use that feedback to improve the application or inform the design

For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?

> Use **short** bullet points…

- Application can be easily loaded and is free of application breaking bugs
- Design across the application is rudimentary but functional
- Design of client side is functional but unclear.
- Report details the application functionality but lacks any engagement with prior art, research, literature and does not evidence any engagement with the wider web development world

For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

> Use **short** bullet points…

- Application functions well with no obvious bugs
- The main functionality of the application is covered with appropriate unit tests
- The client side is easily understandable and easy to use
- The report gives a clear account of how the application was designed included the literature, research and prior-art that informed the design of the application
- User testing was appropriately gathered and has been used to inform the design of the application.
- Report is written to a good standard of english

For this brief, what would an **outstanding** (e.g. 1st) student project look like?

> Use short bullet points…

- All areas of the application (front end, unit testing, data store/model, etc…) are implemented to a highly polished standard
- Client side interface is clear and usable to an exemplary standard
- Minimal bugs are present in the code
- Unit testing exhaustively covers the application's functionality, all student code and tests all possible failure modes
- Extensive user testing that has informed the design of the application at all stages
- Students would make use of realtime web technologies (such Web Sockets)
- Report is written to an excellent standard, with detailed information on the literature, research and prior-art that informed the project
- The report is highly detailed with extensive self-reflection about the design and implementation processs
- The report reflects clearly on what has worked well and what has not and provides insight in to future directions.

# CM3020 - Artificial Intelligence

## Project Idea Title 1: Kane and Abel: AIs that play games

## What problem is this project solving?
Write this as one SHORT question.

## What is the background and context to the question above in 150 words or fewer?
The problem is to implement and compare different approaches to playing games with AIs.

This project involves the implementation of two AI systems (Kane and Abel) which can play the same game. One system should have a pre-programmed,  behaviour, for example using a finite state machine or other appropriate method. The other system should use some sort of statistical machine learning techniques to learn how to play the game. It is acceptable to adapt the second, machine learning based AI from published source code but the first AI should be written by the student.

AI researchers have long seen game playing as an excellent testbed for AI techniques, and as a marker of the state of the art in AI. There is a wealth of background work covering a wide range of AI techniques and how they can be used to develop game playing AIs. In this project, the student has an opportunity to dive into this fascinating body of work and to attempt to build their own systems.

## List some recommended sources for students to begin their research
- Świechowski, Maciej. "Game AI competitions: Motivation for the imitation game-playing competition." 2020 15th Conference on Computer Science and Information Systems (FedCSIS). IEEE, 2020.
  → great recent reference for the various AI game player competitions out there

- Justesen, Niels, Michael S. Debus, and Sebastian Risi. "When are we done with games?." 2019 IEEE Conference on Games (CoG). IEEE, 2019.
  → Some interesting thoughts about the motivations and future of AI game players

- Mnih, Volodymyr, et al. "Human-level control through deep reinforcement learning." nature 518.7540 (2015): 529-533.
  → classic paper about DQN and Atari

## What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

Presentation: We would expect the student to present in various media, detailed information about the following:

- Review of related work, especially the background to the two game playing system designs
- Description of the game that the AIs will play
- Description of the implementation of the two AI systems
- Properly organised and commented source code for the two implementations

- Evaluation of the two systems, and comparison to human players if appropriate

## What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

We recommend that at the prototype stage, the student should have the simulation environment up and running and that they should have at least one of the AI systems interacting with the environment.

## What kinds of techniques/processes are relevant to this project?
- Review of relevant literature and description of the problem domain
- Explaining how the systems interact with the game environment
- Programming the two AI systems, noting that the machine-learning based one might be adapted from published code (e.g. DQN etc.)
- Describing the implementation of the two systems
- Evaluating the performance of the two systems and measuring the effect of different settings

## What would the output of these techniques/processes look like?
- Review of relevant literature and description of the problem domain
  - Section in the report describing similar work in the literature and describing the problem domain
- Explaining how the systems interact with the game environment
  - Section in the report
- Programming the two AI systems, noting that the machine-learning based one might be adapted from published code (e.g. DQN etc.)
  - Well organised and commented code
- Describing the implementation of the two systems
  - Detailed technical description in the report
- Evaluating the performance of the two systems and measuring the effect of different settings
  - Presentation of appropriate tables, graphs and commentary showing how the systems perform

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)?
### What criteria are important?
We would expect the student to evaluate the following elements:

- Are the AIs able to interact with the game?

- Are the AIs well described and implemented according to a specification?
- How well do the AIs perform?
- Is the code well organised and well commented?
- Is it absolutely clear which code has been written by the student and which has not?
- Are the descriptions in the report sufficient for a tutor to understand how the code works and how the system has been evaluated?

### For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?
- Brief but limited review of the literature
- Working but simplistic attempt at implementing at least one AI game player
- Limited evidence of evaluation
- Limited but complete report

### For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?
- Review of the literature which shows evidence of wide reading
- Working attempts at implementing two AI game players, with evidence of significant, iterated development effort on the part of the student
- Well presented evidence of meaningful evaluation of the two AIs
- Complete, clearly written report

### For this brief, what would an **outstanding** (e.g. 1st) student project look like?
- Extensive review of the literature which shows evidence of wide reading and critique of previous work
- Two fully working AI game players, with significant and challenging technical effort involved in their implementation by the student
- Evidence of extensive evaluation and iterated development of different aspects of the AI game players.
- Complete, clearly written report

# Project Idea Title 2: Automated design using evolutionary computation

## What problem is this project solving?

The problem is how to automate the design of complex, possibly moving structures. For example, moving robots or neural networks.

This project involves the creation of a system which uses evolutionary computing or artificial life techniques to carry out a directed exploration of a space of possibilities. It is up to the student to define what the space represents – the example seen in the AI course was the space of possible forms for 3D creatures. The method of exploration is also up to the student, again, the example seen in the AI course was to direct the exploration towards creatures with desirable characteristics. A successful project will contain a functional system with a well defined space and a well defined method for exploring that space.

## What is the background and context to the question above in 150 words or fewer?

Statistical machine learning techniques currently dominate in many problem domains such as image analysis and speech analysis. However, there is another class of problem where the technique of learning statistical patterns in large datasets cannot necessarily be applied. Evolutionary computation and artificial life techniques can be applied to problems where there is minimal data available and no pre-existing correct and incorrect solutions.

## List some recommended sources for students to begin their research

- Lehman, Joel, et al. "The surprising creativity of digital evolution: A collection of anecdotes from the evolutionary computation and artificial life research communities." Artificial life 26.2 (2020): 274-306.
  - → an introduction to a range of systems that evolve forms
- Sims, Karl. "Evolving virtual creatures." Proceedings of the 21st annual conference on Computer graphics and interactive techniques. 1994.
  - → classic paper evolving moving creatures
- Yee-King, Matthew John. "The use of interactive genetic algorithms in sound design: a comparative study." Computers In Entertainment 14.3 (2016).
  - → evolving sound synthesis circuits
- Thompson, Adrian. "An evolved circuit, intrinsic in silicon, entwined with physics." International Conference on Evolvable Systems. Springer, Berlin, Heidelberg, 1996.
  - → classic paper about evolving circuits -might be possible with a cheap, modern day FPGA, but challenging!

## What would the final product look like?

*(e.g. presentation, usability, functionality, results)?*

Presentation: We would expect the student to present in various media, detailed information about the following:

- Review of related work
- What is the problem the system is addressing?
- How has the solution space been represented parametrically – how are the solution represented at a data level and how are they expressed such that they can be tested?
- How does the algorithm work?

- How well does the system perform? Do the solutions improve over the runtime of the algorithm? * How did the student overcome challenges and make changes to the encoding scheme, testing environment and so on to improve the system's performance?

## What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

We recommend that at the prototype stage, the student has specified and ideally, implemented the encoding scheme. So it should be clear what the problem is (e.g. designing robots, designing buildings etc.) and how the system encodes the problem space (e.g. genetic encoding scheme). The student should also have a clear and viable technical plan for how the potential solutions can be evaluated (e.g. running robots in simulation).

## What kinds of techniques/processes are relevant to this project?

- Review of relevant literature and description of the problem domain
- Encoding solutions in a manner that is appropriate for the application of evolutionary computing
- Designing a fitness function suitable for measuring the performance
- Using a genetic algorithm to iteratively evolve a population of solutions to a well specified problem
- Ensuring the evaluation of solutions is efficient enough to allow the evaluation of thousands of solutions in a reasonable time
- Evaluating the performance of the system as a whole and measuring the effect of different settings

## What would the output of these techniques/processes look like?

- Review of relevant literature and description of the problem domain
  - Section in the report describing similar work in the literature and describing the problem domain
- Encoding solutions in a manner that is appropriate for the application of evolutionary computing
  - Genetic encoding scheme clearly described in the report and implemented in code
- Designing a fitness function suitable for measuring the performance
  - Fitness function(s) clearly described and implemented in code
- Using a genetic algorithm to iteratively evolve a population of solutions to a well specified problem
  - Genetic algorithm implemented (can use a pre-made library if that helps), genetic operators, selection and breeding working
- Ensuring the evaluation of solutions is efficient enough to allow the evaluation of thousands of solutions in a reasonable time
  - Measurements of how long it takes to evaluate solutions and demonstrating that this allows meaningful evolution.

- Evaluating the performance of the system as a whole and measuring the effect of different settings
    - Evidence presented in the report of multiple runs of the system showing variation in performance between runs. A comparison of runs with different parameter settings.

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)?

### What criteria are important?

- Does the encoding scheme work?
- Does the fitness function work?
- Does the overall algorithm work, i.e. do the solutions improve as the algorithm proceeds?
- How do features of the encoding scheme, fitness function and evolutionary algorithm impact on the performance? Can you compare performance with different features enabled or disabled?
- Is the code well organised and well commented?
- Is it absolutely clear which code has been written by the student and which has not?
- Are the descriptions in the report sufficient for a tutor to understand how the code works and how the system has been evaluated?

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?

- Brief but limited review of the literature
- Working but simplistic encoding scheme with examples of genetic data and how that is converted into solutions
- Working fitness function
- Limited evidence of evaluation
- Limited but complete report

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?

- Review of the literature which shows evidence of wide reading
- Working encoding scheme with examples of genetic data and how that is converted into solutions
- Working fitness function
- Evidence of effort to optimise the performance of the system
- Evidence of meaningful evaluation of different aspects of the encoding scheme, fitness function etc.
- Evidence of significant technical work on the part of the student
- Complete, clearly written report

## For this brief, what would an outstanding (e.g. 1st) student project look like?

- Extensive review of the literature which shows evidence of wide reading and critique of previous work
- Working encoding scheme with examples of genetic data and how that is converted into solutions

- Working fitness function with multiple elements
- Evidence of successfully optimising the performance of the system
- Evidence of extensive evaluation and further development of different aspects of the encoding scheme, fitness function etc. involving challenging technical work by the student
- Complete, clearly written report

# CM3005 Data Science

## Project Idea Title 1: Automated search strategy generation

### What problem is this project solving?
Can you automatically generate a search strategy from a job description?

### What is the background and context to the question above in 150 words or less?
Finding the right information at the right time is a constant challenge. Sometimes, a few keywords in a search box are good enough. But there are times when a more rigorous, precise approach is needed. Up to now, the traditional solution has been to use 'advanced search' or specialist 'line-by-line' query builders. However, these require the use of complex Boolean expressions and offer limited support for error checking or optimization.

The goal of the project is to investigate ways in which automated support might be provided. For example, given a natural language job description, can we automatically generate an effective search strategy that finds social profiles of suitable candidates? What kinds of terms should be extracted, and how should they be structured? How might we evaluate such a tool?

### List some recommended sources for students to begin their research
- https://insights.dice.com/report/build-better-boolean-searches-strings/
- https://www.2dsearch.com/recruiters
- https://www.2dsearch.com/news/2018/9/11/a-new-way-to-view-your-old-searches
- https://youtu.be/tJ3fBRvszhQ
- https://www.2dsearch.com/research

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The deliverable should be a working prototype and some evaluation of its performance (test data can be provided). It should take the form of a Python class/package that can be run from the command line. A more polished version could provide a graphical user interface, but the key evaluation criteria are breadth of functionality and accuracy.

### What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A basic baseline model that generates search queries from natural language, but is not expected to perform well (e.g choosing the 5 most common key words in the text as a search query)

## What kinds of techniques/processes are relevant to this project?
NLP (information extraction)

Information Retrieval

Data visualization

## What would the output of these techniques/processes look like?
A pipeline as described above

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?
## What criteria are important?
Evaluation: to what extent does it find suitable candidates?

Test data can be provided

## For this brief, what would a **minimum pass** (e.g. 3$^{rd}$) student project look like?

- A basic NLP pipeline for processing job adverts
- A generation strategy for search terms that performs better than a simple baseline
- An appropriate evaluation of the model

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?
It should meet the minimum pass criteria and in addition:

- The NLP pipework has been tested, and works on a wide range of data
- A suitable data set has been developed
- The query generation strategy performs with high accuracy
- The pipelines has been thoroughly evaluated with appropriate methods

## For this brief, what would an **outstanding** (e.g. 1$^{st}$) student project look like?
It should meet the minimum pass criteria and in addition:

- A high quality and possibly publishable data set has been developed
- The generation strategy is somewhat or highly novel
- The generation strategy performs with state of the art accuracy
- The pipelines has been thoroughly evaluated to the standard of academic research

# Project Idea Title 2: Generating query suggestions using Linked Open Data

## What problem is this project solving?
Can you generate search query suggestions using Linked Open Data?

## What is the background and context to the question above in 150 words or less?
Knowledge workers (such as healthcare information professionals, patent agents and recruitment professionals) undertake work tasks where search forms a core part of their duties. In these instances, the search task is often complex and time-consuming and requires specialist expert knowledge to formulate accurate search strategies. Interactive features such as query expansion can play a key role in supporting these tasks.

You can see an example of this in practice at https://app.2dsearch.com/. However, the current NLP API would be significantly more valuable if it included:

- Mesh Entry Terms (https://id.nlm.nih.gov/mesh/)
- Wikidata (https://www.wikidata.org/wiki/Wikidata:Data_access#SPARQL_endpoints)
- ConceptNet (http://conceptnet.io/)

These are publicly accessible as SPARQL endpoints. The goal of this project is to investigate one or more of these services, extract query suggestions from them and then evaluate them to find an optimal combination. We have plenty of test data for this.

## List some recommended sources for students to begin their research
- https://youtu.be/tJ3fBRvszhQ
- https://www.2dsearch.com/news/2018/9/11/a-new-way-to-view-your-old-searches
- https://www.2dsearch.com/research
- https://journals.sagepub.com/doi/full/10.1177/02663821211034079
- https://www.2dsearch.com/news/2020/3/18/nlp-techniques-for-automated-query-suggestions

## What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The deliverable should be a working prototype and some evaluation of its performance (test data can be provided). It should take the form of a Python class/package that can be run from the command line. A more polished version could provide a graphical user interface, e.g. via Flask/Swagger, but the key evaluation criteria are breadth of functionality and accuracy.

## What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A basic baseline model that generates search queries from structured data, but is not expected to perform well (e.g choosing the 5 most common key words in the text as a search query)

## What kinds of techniques/processes are relevant to this project?

NLP (information extraction)

Information Retrieval

Python

## What would the output of these techniques/processes look like?

A software module as described above

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?
## What criteria are important?

Evaluation: to what extent does it generate suitable query suggestions? (e.g. using metrics such as precision and recall)

Test data can be provided

## For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?

- A basic data pipeline for processing linked data
- A generation strategy for search terms that performs better than a simple baseline
- An appropriate evaluation of the model

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

It should meet the minimum pass criteria and in addition:

- The data pipework has been tested, and works on a wide range of data
- A suitable data set has been developed
- The query generation strategy performs with high accuracy
- The pipelines has been thoroughly evaluated with appropriate methods

## For this brief, what would an **outstanding** (e.g. 1st) student project look like?

It should meet the minimum pass criteria and in addition:

- A high quality and possibly publishable data set has been developed
- The query generation strategy is somewhat or highly novel
- The query generation strategy performs with state of the art accuracy
- The pipelines has been thoroughly evaluated to the standard of academic research

# CM3010 Databases and Advanced Data Techniques

## Project Idea Title 1: Convert an existing Open Data resource into Linked Data and connect it to something else (example: concert data)

### What problem is this project solving?

Combining datasets allows more powerful search and knowledge discovery. An example is cncert data where many organisations publish information, but it can not be cross-referenced.

### What is the background and context to the question above in 150 words or less?

Publishing open data is a useful activity, but if the data is valuable, it is often useful to combine it with other data sets, often in other topics. Creating a Linked Data resource and connecting it with others is a powerful tool for this.

### List some recommended sources for students to begin their research

- The NY Philharmonic concert data is available as XML and JSON
- Carnegie Hall data is available as linked data (but may need improvement)
- The Live Music Archive (archive.org) has huge amounts of concert  data
- Musicbrainz provides rich information about pieces, performers and recordings. It isn't linked data, but every element has a URI, so can be used for Identification
- OpenRefine and WebKarma are potentially useful tools for aligning data sets. Otherwise, a language like Python or JS can be supported by librdf and string matching libraries (such as fuzzywuzzy)

### What would the final product look like?

*(e.g. presentation, usability, functionality, results)?*

The  finished  product should include:

- A linked data resource (triplestore or set of RDF files)
- Either  a website that uses the combined data or data analysis in the  report made possible by the data combination

### What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

The prototype must show a viable workflow to get data from the source to its final, aligned form, including an explicit data model. There should be a clear benefit over the prior situation (separate

open resources). A method for aligning entities from both resouces must be demonstrated as feasible.

## What kinds of techniques/processes are relevant to this project?
- Data modelling
- Data transformation
- Data cleaning/alignment
- Search and analysis
- Web development (potentially)
- Web scraping (potentially)

## What would the output of these techniques/processes look like?
- Data (RDF)
- Analyses
- Alignment software (potentially)

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?
## What criteria are important?
- Are research questions on the data clear?
- Does the model support the questions?
- Is the model supported by the data?
- Is the data or the alignment reliable?

## For this brief, what would a **minimum pass** (e.g. 3$^{rd}$) student project look like?
- Data has been taken through an at least partially automated pipeline, resulting in valid RDF
- Analysis has been undertaken that explicitly relates the source data to another resource

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?
- Significant amounts of rich data have been taken through a pipeline which is automated, where possible, resulting in valid RDF
- The data model is appropriate both to the data being transformed and the data being linked to, with compatible ontologies chosen and as few new terms as possible
- Analysis generates observations that would be impossible (or awkward) without the linking

## For this brief, what would an **outstanding** (e.g. 1$^{st}$) student project look like?
- A reusable, mostly automated pipeline produces a resource that could be of value beyond the project (this could be a github project that the original data publisher could themselves adopt)

- Modelling that shows strong analytical skills. A resulting ontology that minimises new terms, but demonstrably improves on previous work.
- Analysis that produces interesting observations that are contextualised within the domain (e.g. for music concerts, summarising historical changes in people's tastes)

# Project Idea Title 2: Convert between XML formats, updating a dataset (example: CMME)

## What problem is this project solving?

XML (and SGML before it) have been used to construct data encoding standards for long enough that multiple, incompatible datasets have come about. Moving between these formats is often possible using XSLT or XQuery, but making a converter requires knowledge of both data models. In some cases, automatic conversion may be impossible, and user input may be needed.

## What is the background and context to the question above in 150 words or less?

Use XSLT or XQuery to create conversion software between formats. In our example, a specialised music notation encoding format, CMME, is being replaced by MEI, but has a lot of valuable early music (pre-1600) already in it. As yet, conversion between these formats is not possible.

## List some recommended sources for students to begin their research

- Find appropriate XML formats to consider (Wikipedia has some lists).
- CMME is well document by Theodor Dumitrescu (its creator) at cmme.org
- MEI is documented at music-encoding.org. It also has an active mailing list and Slack community.
- There are many helpful XSLT/XQuery guides – O'Reilly books are excellent on this

## What would the final product look like?

*(e.g. presentation, usability, functionality, results)?*

The finished product should include:

- Conversion code (with interaction if needed)
- Sample converted data (ideally, some implemented as unit tests)
- Documentation of how to use the converter
- Evaluation of the conversion – what is lost/gained/distorted

## What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

The prototype should implement the main features of the format. Accuracy is important, but if there is distortion or information loss, then this must be explicitly evaluated in the report.

## What kinds of techniques/processes are relevant to this project?

- Data modelling
- Data transformation

- Interaction design (potentially)

## What would the output of these techniques/processes look like?
- Code and documentation
- Transformed data

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?

## What criteria are important?
- Have you understood the format and source data?
- Have you made the model of the target format explicit? Can it support the source format?
- Is interaction needed for the conversion? Is that appropriately handled?
- Does the resut work with any existing tools?

## For this brief, what would a **minimum pass** (e.g. 3<sup>rd</sup>) student project look like?
- Data has been taken converted, and the main structures are intact
- The process is documented, so that any lost data is explicitly recorded

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?
- Conversion produces mostly complete documents
- The data model is explicitly considered, and any mismatch with the source format is resolved appropriately
- Any user interaction required is either appropriately handled or its exclusion justified
- Existing tools run on the resulting dataset

## For this brief, what would an **outstanding** (e.g. 1<sup>st</sup>) student project look like?
- A complete or substantially complete conversion.
- Modelling is accurate and shows engagement with the domain in which the format sits
- User interaction is minimised and, if it is necessary, supports users in making appropriate decisions
- A significant dataset is converted and made available to the community (e.g. on GitHub).
- Robust testing allows informed evalutation of the results
- Good evaluation of the conversion and the resulting data quality

# CM3060 Natural Language Processing

## Project Idea Title 1: Fake news detection

### What problem is this project solving?
Can you tell the difference (programmatically) between real and fake news?

### What is the background and context to the question above in 150 words or less?
We live in an age of information, disinformation and misinformation. Can you tell the difference? Fake news is disinformation and misinformation spread through social media and other online forums. It often consists of hoaxes, groundless conjecture and exaggerated, unfounded claims. This may be done to promote certain ideas or beliefs and is often associated with specific political agendas. Fake news is often further propagated by algorithmic means, resulting in users being trapped (willingly or otherwise) in their own filter bubble.

### List some recommended sources for students to begin their research
- https://data-flair.training/blogs/advanced-python-project-detecting-fake-news/
- https://en.wikipedia.org/wiki/Fake_news
- https://www.bbc.co.uk/news/topics/cjxv13v27dyt/fake-news
-

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The output should be a software module that differentiates between real and fake news, as described above. It should be embodied as a Jupyter Notebook, using Python. This should consist of sections such as the following:

- Analysis / exploration of the data set
- Identification of suitable features and implementation of a suitable feature extractor, e.f. TfidfVectorizer
- Implementation of appropriate ML classifier(s)
- Some evaluation of the output, e.g. confusion matrices, accuracy, etc.

### What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A basic data processing pipeline and a very basic classifier that can act as a baseline for future evaluation (e.g. keyword spotting). This does not need to have high accuracy at this stage, just demonstrate the pipeline.

## What kinds of techniques/processes are relevant to this project?

- Feature extraction
- Classification algorithms
- Evaluation methods

## What would the output of these techniques/processes look like?

- Feature extraction: an appropriate set of features
- Classification algorithms: a comparison of various methods
- Evaluation methods: some analysis of their performance

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)?

## What criteria are important?

By accurately differentiating between real and fake news, and applying an objective evaluation function.

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?

- An implementation comparable with published studies (see above)
- An accuracy score comparable with published studies
- A suitable evaluation of the method

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?

- An investigation of multiple methods
- A high quality evaluation and comparison of the methods using good quality evaluation methods
- An accuracy score comparable to the benchark set in published studies

## For this brief, what would an outstanding (e.g. 1st) student project look like?

- An investigation of multiple methods
- An evaluation of the methods to the standard of academic research
- An accuracy score equal to or above the benchark set in published studies
- Some insight into the explainability of the methods, e.g. which features are indiciative of fake news

## Project Idea 2: Generating related terms using Linked Open Data

### What problem is this project solving?
Can you generate related terms using Linked Open Data?

### What is the background and context to the question above in 150 words or less?
Finding related terms is useful for all manner of applications, such as information retrieval, document summarization, document authoring, etc. You can see an example of related terms being used a source of query suggestions at  https://app.2dsearch.com/. This uses a variety of Linked Open Data endpoints to generate those terms, such as DBPEDIA, WEBISA and MeSH. These are publicly accessible as SPARQL endpoints.

However, there are many more sources of related terms, such as:

- Mesh Entry Terms (https://id.nlm.nih.gov/mesh/)
- Wikidata (https://www.wikidata.org/wiki/Wikidata:Data_access#SPARQL_endpoints)
- ConceptNet (http://conceptnet.io/)

The goal of this project is to investigate one or more of these services, extract related terms from them and then evaluate them to find an optimal combination. We have plenty of test data for this.

### List some recommended sources for students to begin their research
- Linked Open Data: https://en.wikipedia.org/wiki/Linked_data
- DBPEDIA: https://www.dbpedia.org/resources/sparql/
- A comparison of query suggestion methods: https://journals.sagepub.com/doi/full/10.1177/02663821211034079
- Generating related terms: https://www.youtube.com/watch?v=JsfPmhfi9-4&t=2s
- NLP techniques for automated query suggestions: https://www.2dsearch.com/news/2020/3/18/nlp-techniques-for-automated-query-suggestions

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The deliverable should be a working prototype and some evaluation of its performance (test data can be provided). It should take the form of a Python class/package that can be run from the command line. A more polished version could provide a graphical user interface, e.g. via Flask/Swagger, but the key evaluation criteria are breadth of functionality and accuracy.

### What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A basic baseline model that generates related terms from structured data, but is not expected to perform well (e.g choosing the 5 most common key words in the text as a search query)

## What kinds of techniques/processes are relevant to this project?
NLP (information extraction), Linked Open Data

Information Retrieval

Python

## What would the output of these techniques/processes look like?
A software module as described above

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)?
## What criteria are important?
Evaluation: to what extent does it generate suitable related terms? (measured using metrics such as precision and recall against a 'gold standard' data set)

Test data can be provided.

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?
- A basic data pipeline for processing linked data
- A generation strategy for related terms that performs better than a simple baseline
- An appropriate evaluation of the model

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?
It should meet the minimum pass criteria and in addition:

- The data pipework has been tested, and works on a wide range of data
- A suitable data set has been developed
- The query generation strategy performs with high accuracy
- The pipeline has been thoroughly evaluated with appropriate methods

## For this brief, what would an outstanding (e.g. 1st) student project look like?
A software module that inputs query terms and outputs related terms with high accuracy, and compares the performance against distributional NLP language models (e.g. BERT)

It should meet the minimum pass criteria and in addition:

- A high quality and possibly publishable data set has been developed
- The query generation strategy is somewhat or highly novel
- The query generation strategy performs with state of the art accuracy
- The pipelines has been thoroughly evaluated to the standard of academic research

# CM3065 Intelligent Signal Processing

## Project Idea Title 1: Camera Surveillance System

### What problem is this project solving?
Developing a home security camera system for indoor surveillance.

### What is the background and context to the question above in 150 words or less?
Home security camera systems have exploded in popularity over the past few years. Nowadays, it is possible to install a professional security camera system at home at an affordable price.

However, some users do not want video and photos from inside their houses being shared with a third party, and they prefer to build their own surveillance camera systems using low-cost micro-computers and cameras, and developing their own applications.

### List some recommended sources for students to begin their research

- S. Brutzer, B. Höferlin and G. Heidemann, "Evaluation of background subtraction techniques for video surveillance," CVPR 2011, 2011, pp. 1937-1944, doi: 10.1109/CVPR.2011.5995508. URL: https://ieeexplore.ieee.org/abstract/document/5995508

  Abstract (excerpt): Background subtraction is one of the key techniques for automatic video analysis, especially in the domain of video surveillance. Although its importance, evaluations of recent background subtraction methods with respect to the challenges of video surveillance suffer from various shortcomings.

- Y. Jusman, L. Hinggis, R. O. Wiyagi, N. A. M. Isa and F. Mujaahid, "Comparison of Background Subtraction and Frame Differencing Methods for Indoor Moving Object Detection," 2020 1st International Conference on Information Technology, Advanced Mechanical and Electrical Engineering (ICITAMEE), 2020, pp. 214-219, doi: 10.1109/ICITAMEE50454.2020.9398484. URL: https://ieeexplore.ieee.org/document/9398484

  Abstract (excerpt): This study analyzes the method of moving object detection using video images by comparing two methods, namely background subtraction and frame differencing.

- N. Srivastav, S. L. Agrwal, S. K. Gupta, S. R. Srivastava, B. Chacko and H. Sharma, "Hybrid object detection using improved three frame differencing and background subtraction," 2017 7th International Conference on Cloud Computing, Data Science & Engineering - Confluence, 2017, pp. 613-617, doi: 10.1109/CONFLUENCE.2017.7943225. URL: https://ieeexplore.ieee.org/document/7943225

  Abstract (excerpt): Object Detection and Tracking in video has applied in robotics, video-surveillance; human-computer interaction etc. and different approach of object detection e.g. Background subtraction, frame differencing. […] Two frame differencing is very easy but

there is problem of holes. […] In this paper, the proposed technique is able to reduce the holes problem in dynamic background updating video.

- Shaikh S., Saeed K., Chaki N. (2014) Moving Object Detection Using Background Subtraction. In: Moving Object Detection Using Background Subtraction. SpringerBriefs in Computer Science. Springer, Cham.
URL: https://link.springer.com/chapter/10.1007/978-3-319-07386-6_3

Abstract: Background subtraction is a widely used approach for detecting moving objects from videos captured with static a camera. This chapter introduces the basic concept behind this approach using a simple frame differencing method. A survey on existing literature on this topic is also reported in this chapter.

## What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final product will be a fully functional indoor home security camera system which will allow us to detect intruders in a room. (*)

The core of the system will be a movement detection application that will have the following characteristics:

- Captures and stores video once any kind of motion takes place in the room.
- Sends an 'alarm' message to the phone of a supervisor (an email, for example) describing the problem detected.
- Uploads the video to a web dashboard, along with meta data describing what is going on (for example, the application can detect if the intruder appears to the right or left of the frame, guess if the intruder is an animal or a person – 'small' vs 'big' intruder – etc.).

The system also includes a web dashboard that should let a supervisor see the generated videos, read the video meta data, review the clips, remove the clips, etc.

The video clips uploaded to the web dashboard will have a maximum length of 20 seconds.

(*) We can suppose that there is any pet in the room, so any animal in the room (cat, dog, bird, etc.) can be considered as an 'intruder'.

## What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

Prototype needs to focus on the movement detection application for detecting intruders and on the triggering of the alarm.

The development of the web dashboard, as well as the video storing and uploading, are not important at this stage.

## What kinds of techniques/processes are relevant to this project?

- Iterative development
- Frequent testing
- Computer vision: movement detection
- Frame differencing and background subtraction techniques
- Audio and video file formats. Compressing audio and video.
- Python, OpenCV and ffmpeg is strongly recommended.

## What would the output of these techniques/processes look like?

- A series of incrementally improving prototypes – showing how you have tested and incorporated the results from these tests.

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?

## What criteria are important?

Student will simulate different intruders attacks at different times during the day. Student will check if the movement detection application is functioning properly (i.e. if the alarm triggers when an intruder enters into the room) for any intruder and behaviour, and under any room lighting conditions.

Student will also check that the alarm message is immediately received by a supervisor, who should be able to verify the authenticity of the warning message viewing the video clips uploaded to the system web dashboard.

## For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?

- The movement detection application captures and stores video when it detects motion in the room. The application sends a warning to the phone of a supervisor, who can verify this warning examining the video clips uploaded to the web dashboard. The whole process is performed without major issues.
- The web dashboard is functional, although it has a poor user interface design.
- Written report lacks research, detail of process, issues encountered in production, and/or does not reference correctly.

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

- The movement detection application is based on a simple but effective method for moving object detection.
- The automatic analysis of the clips generates useful and mostly correct information about the problem detected. This information is both sent in the alarm message and saved as meta data within the video file.
- The movement detection application is able to automatically adapt the application algorithm to different rooms and lighting conditions.

- The web dashboard has a user-friendly design.
- The surveillance system generates video clips in a correct format – in terms of balance between quality and size, and browser compatibility – although it could be improved.
- The report is well written and it describes the methods, algorithms and processes implemented, as well as details the issues encountered in production.


For this brief, what would an **outstanding** (e.g. 1$^{st}$) student project look like?
- The movement detection application is based on a sophisticated and very effective method for moving object detection.
- The automatic analysis of the clips generates mostly correct and detailed information about the problem detected. This information is both sent in the alarm message and saved as meta data within the video file.
- The movement detection application includes a sophisticated method to adapt the application algorithm to different rooms and lighting conditions.
- The web dashboard is highly-polished in terms of design and usability.
- The surveillance system generates video clips in an optimal format in terms of balance between quality and size, and browser compatibility.
- The report is flawlessly written. Excellent spelling and grammar. Appropriate academic tone is taken throughout. The report describes the methods, algorithms and processes implemented, as well as details the issues encountered in production.

## Project Idea Title 2: VJing system

## What problem is this project solving?
Developing a web-based VJing application with audio processing.

## What is the background and context to the question above in 150 words or less?
The number of artists/hackers/musicians who utilise the browser for developing audio visual applications is increasing steadily. Web languages such as HTML5 and JavaScript have turned the browser into a powerful tool for audio visual creation.

These applications include VJ engines, which are used by VJs to create or manipulate imagery in realtime through technological mediation in synchronization to music.

## List some recommended sources for students to begin their research
- Beact: DJ and VJ All By Yourself in Seconds on Web
  Beact is a web-based instrument based on JavaScript and the libraries Two.js and Tone.js – as audio and visual engine library respectively – that 'everyone can play with to become a DJ + VJ'.
  URL: https://medium.com/@vibertthio/dj-and-vj-all-by-yourself-in-seconds-on-web-e5befc162e0f

- Visual Fiha
  The Visual Fiha web app is a web-based live coding VJing app with audio processing and MIDI control support. The last version of Visual Fiha is based on HTML5, JavaScript and the libraries Three.js, P5, React.js and Redux among others.
  URL: https://visual-fiha.gitlab.io/

- Neromute
  Neromute is a web-based Visual Synth / VJ toy developed in HTML5.
  URL: https://neuromute.virusav.com/

## What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final product will be a fully configurable web-based VJing system with audio processing.

The VJing system will have the following characteristics:

- Loads video files, audio files, or a combination of those. It can also use a camera input and audio input as a video and audio source.
- Includes a modular node-based patching environment (similar to a graph flow language such as PureData) to process, mix and generate audio and video materials. Audio input and camera input can also be processed in the patching environment. (*)
- Has separate control panel and visualiser windows so it can be used with a projector

(*) For illustrating the idea of node-based patching environment, see also Resolume Wire
http://resolume.com/blog/20649/welcome-to-wire


## What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

Prototype must show the functioning of the modular node-based patching environment. It must allow the use a camera input and audio input as a video and audio source, and has separate control panel and visualiser windows.

It is not necessary to develop a large number of video and audio effects at prototype stage. User interface can be very simple at this stage.


## What kinds of techniques/processes are relevant to this project?

- Iterative development
- Frequent testing
- Extracting features from audio signals.
- Processing video data.
- Capturing, representing and processing camera input.
- HTML5, JavaScript, Web Audio API, p5.js, Two.js, Tone.js, Meyda, etc.


## What would the output of these techniques/processes look like?

- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from beta testers.
- Several sets of feedback from beta testers that inform your ongoing development and design process.


## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)?
## What criteria are important?

Student will use beta testers and solicit feedback on the developing application. Main source of data will be beta testers opinions and, where possible, player actions where it's possible to directly observe playtesting.


## For this brief, what would a minimum pass (e.g. 3rd) student project look like?

- The application meet all the requirements and can be loaded, and used without major bugs/crashes.
- The GUI is functional, although it has a poor design.

- The result from an aesthetic perspective is very poor. The program is very limited and lacks of interesting audio and video effects.
- Written report lacks research, detail of process, issues encountered in production, and/or does not name influences or audio-visual assets used appropriately.

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?

- The application meet all the requirements and functions well without bugs.
- The application has a user-friendly design, and it is easy to start using the program.
- The program includes interesting audio and video effects (patches), which can be freely patched. The program also alows to configure mappings between visual variables and audio features.
- The application allows one to generate interesting results from an aesthetic perspective.
- The report is well written and it describes the architecture of the program effects, algorithms and processes implemented, as well as details the issues encountered in production.

## For this brief, what would an outstanding (e.g. 1$^{st}$) student project look like?

- The application is highly-polished in terms of design and usability.
- The patching environment includes several useful and interesting patches, which can be freely patched. The program also alows to create complex mappings between visual variables and audio features.
- The application has been very well designed and allows one to mix and processe several sources simultaneously in real-time.
- The application allows one to generate stunning results from an aesthetic perspective (audio and video).
- The report is flawlessly written. Excellent spelling and grammar. Appropriate academic tone is taken throughout. The report describes the architecture of the program effects, algorithms and processes implemented, as well as details the issues encountered in production.

# CM3030 Games Development

## Project Idea Title 1: Arcade Game

### What problem is this project solving?
Creating an easily understandable (pick up and play) single-player game that is challenging but which is compelling and replayable – just like 80s/90s arcade games.

### What is the background and context to the question above in 150 words or less?
In the early history of videogames, arcade games were king. They were the main way that people played digital games, and the business model (pay to play / pay per credit) encouraged a certain design philosophy – difficult games which were compelling and encouraged people to want to play again and improve their performance.

### List some recommended sources for students to begin their research
- The Internet Arcade: https://archive.org/details/internetarcade
  - Online emulator where you can play most arcade games of importance in the browser, courtesy of archive.org.
- MAME: https://www.mamedev.org/
  - The main arcade machine emulator used to extensively document and catalogue arcade games of the past.
- An incredibly in-depth dive into the history, making of and mechanics of Pac-man – one of the most important video games of all time: https://web.archive.org/web/20201128174945/https://www.gamasutra.com/view/feature/132330/the_pacman_dossier.php?page=1
  - (You are not expected to be this detailed, this is here as an example of how much thought can go into these games, as well as for interest value and inspiration).
- Titles of some classic videogames to search for: Pacman, Donkey Kong, 1942, Defender, Robotron 2084, Mr. Do, Dig-Dug, Bomb Jack, Space Invaders, Galaxian, Frogger, Asteroids, Ghosts'n'Goblins, Paperboy, Pong, Final Fight, Tapper. There are countless more…!

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final product will be a fully functional video game that would be suitable for play in a public space (e.g. a videogame arcade) on an arcade machine.

It will have a **maximum** gameplay length of 3 minutes.

It will have the following game design characteristics:

- Easy to pick up and start playing (no instructions / minimal instructions required) – it is clear what you have to do.
- Instantly fun and gratifying.

- Simple to understand mechanics which reveal depth through extended play.
- Encourages repeated play.
- Very short initial gameplay sessions due to high difficulty.

It will have the following technical constraints:

- Playable with keyboard arrow keys and up to 3 action buttons ([Z, X, C] or [Ctrl, Alt, Shft]).
    - This is to replicate digital controls and limited number of action buttons used.
    - No analogue controls to be used.
    - YOU CAN ONLY USE: up, left, down, right, action 1, action 2, action 3.
        - You do not need to use all these controls.

It is strongly recommended you develop this game in 2D, rather than 3D, due to the control restrictions

## What would a prototype look like?
*(What would it show? What does it need to prove? What **IS** important to make clear? What is **NOT** important at this stage?)*

Prototype needs to show a core gameplay loop which is challenging, engaging, simple to pick up but which shows strong promise for emergent complexity. It needs to prove you know what the core of your game is, what the player is meant to be doing and how they are going to do it.

Most mechanics and broad aspects of level design should be clear at prototype stage. Graphics and sound are not important at this stage. Prototype is perfectly fine using coloured squares.

## What kinds of techniques/processes are relevant to this project?
- Iterative development
- Frequent playtesting
- Unity/C#.

## What would the output of these techniques/processes look like?
- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from play testers.
- Some aspects of the game have been dropped from the first iterations, some have been added, some have been modified, in line with AGILE development practices.
- Several sets of feedback from players that inform your ongoing development and design process.

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)? What criteria are important?
Student will use play testers and solicit feedback on the developing game. Main source of data will be player opinions and, where possible, player actions where it's possible to directly observe playtesting.

For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?
- Game can be loaded, started and finished without major bugs/crashes.
- Poor audio-visual presentation.
- Gameplay is confusing and/or boring.
- Written report lacks research, detail of process, issues encountered in production, and/or doesn't name influences or audio-visual assets used appropriately.

For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?
- Game functions well without bugs.
- Good audio-visual presentation.
- Gameplay is quickly understandable, it's easy to start playing.
- Game is short fun experience using some well-chosen simple mechanics
- Written report makes clear the challenges faced and how they were overcome. Makes clear the influences that went into the game (e.g. games played and analysed, which mechanics were inspired from where etc.).
- Audio-visual assets appropriately credited.
- Playtesting feedback is clearly gathered and acted on.

For this brief, what would an **outstanding** (e.g. 1st) student project look like?
- Game is highly-polished technically, and in terms of audio-visual presentation.
- Game uses innovative and original mechanics (or well-known mechanics in a novel manner).
- Game requires no instructions – it's very clear what the objective is and how to achieve it from the opening screen.
- Game is easy to start playing, but repeated play shows a well-selected set of simple mechanics that lead to depth and emergent complexity as the player replays the game over several sessions.
- Written report has excellent and concise writing style. Research and influences behind the project are clear and detailed, with extensive analysis of background works.
- Playtesting has been frequent/ongoing, extensive feedback has been gathered and documented and it's very clear how this has been incorporated into the iterative development of the game.
- It is evident there have been several version/iterations of the game, and the challenges at each point have been documented and analysed.

## Project Idea Title 2: PC 'mouse only'/Mobile game

### What problem is this project solving?

Creating an interesting and compelling gaming experience using just a mouse cursor and one button. In this way, the game could appeal to more casual PC games players and could serve as a useful prototype for a mobile game.

### What is the background and context to the question above in 150 words or less?

Both the casual PC and the mobile gaming markets are MASSIVE, catering to a wide range of players who aren't interested in the more 'traditional' gaming experiences offered by consoles or by gaming PCs with complex keyboard-and-mouse or two-handed controllers (which, on average, involve 2 analogue joysticks and 14 buttons to be operated simultaneously). In particular, the increasing power and availability of smart phones has led to a massive increase in mobile phone games players worldwide.

The range of people playing games, and the range of motivations for doing so and interests to be met has never been more diverse.

A design to fit this brief can fit a wide range of game genres. However, you are restricted to games which can be played with mouse-and-single-click-only, which is analogous to games which can be played on mobile using only 1 input at a time / single touch.

### List some recommended sources for students to begin their research

- Google Play Store / iOS App Store Top Games lists.
- https://www.kongregate.com/mouse-only-games
- https://itch.io/games/tag-mouse-only

The above games portals/shop fronts provide much research material for inspiration and analysis. Try to work out what makes a game successful, and possibly how you will make your project different.

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

It would be an engaging game playing experience that is controlled entirely with mouse and single click. It must be playable on desktop, and have a maximum gameplay length of 5 minutes. Shorter and more polished is preferable and will receive higher marks than longer and not as well executed.

You may choose to design any kind of experience that fits within the technical criteria (mouse only, single click/touch, less than 5 minutes gameplay).

The game will be in an appropriate resolution and designed accordingly. e.g. if designing for mobile rather than PC you would need to use larger hotspots for buttons to account for the 'finger-stylus' and may wish to think about using swipe gestures. N.B. Do not use pinch and zoom gestures since this requires multi-touch.

## Project Idea Title 2: PC 'mouse only'/Mobile game

## What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A prototype would show how the controls for the game work and display the essential mechanics of the game. It would use wireframe or place-holder art and basic sounds.

It would need to prove that the game would make an interesting and engaging play experience and make it clear what the player needs to do and how they will go about achieving it.

It does not require complex story, dialogue, detailed art or music and sound at the prototype stage. All that should be left until later on in production.

## What kinds of techniques/processes are relevant to this project?
- Iterative Development
- Frequent playtesting
- Unity/C#.

## What would the output of these techniques/processes look like?
- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from play testers.
- Some aspects of the game have been dropped from the first iterations, some have been added, some have been modified, in line with AGILE development practices.
- Several sets of feedback from players that inform your ongoing development and design process.

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?
## What criteria are important?
Student will use play testers and solicit feedback on the developing game. Main source of data will be player opinions and, where possible, player actions where it's possible to directly observe playtesting.

## For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?
- Game can be loaded, started and finished without major bugs/crashes.
- Poor audio-visual presentation.
- Gameplay is confusing and/or boring.
- Written report lacks research, detail of process, issues encountered in production, and/or doesn't name influences or audio-visual assets used appropriately.

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

- Game functions well without bugs.
- Good audio-visual presentation.
- Gameplay is quickly understandable, it's easy to start playing with little explanation required (i.e. not requiring the reading of long paragraphs of text)
- Game is an interesting, engaging and polished experience.
- Written report makes clear the challenges faced and how they were overcome. Makes clear the influences that went into the game (e.g. games played and analysed, which mechanics were inspired from where etc.).
- Audio-visual assets appropriately credited.
- Playtesting feedback is clearly gathered and acted on.


## For this brief, what would an **outstanding** (e.g. 1st) student project look like?

- Game is highly-polished technically, and in terms of audio-visual presentation.
- Game uses innovative and original mechanics (or well-known mechanics in a novel manner).
- Game requires no instructions – it's very clear what the objective is and how to achieve it from the opening screen.
- Game is easy to start playing, but repeated play shows a well-selected set of simple mechanics that lead to depth and emergent complexity as the player replays the game over several sessions.
- Written report has excellent and concise writing style. Research and influences behind the project are clear and detailed, with extensive analysis of background works.
- Playtesting has been frequent/ongoing, extensive feedback has been gathered and documented and it's very clear how this has been incorporated into the iterative development of the game.
- It is evident there have been several version/iterations of the game, and the challenges at each point have been documented and analysed.

# CM3055 Interaction Design

## Project Idea Title 1: Designing a usable software keyboard for mobile devices

### What problem is this project solving?

An interactive keyboard that proposes a usable proposition for input of alphanumeric characters on small screen devices.

### What is the background and context to the question above in 150 words or less?

The mobile keyboard market is broad, catering to a range of devices and interactive modalities. From basic propositions to touch based-input with haptic feedback to more complex solutions proposing gestures such as swiping, there are a variety of feasible solutions. There are subtle differences in many of the interaction design possibilities proposed by these tools. Are they usable? Accessible? Do they cater to novices and expert users alike? With diverse screen sizes and design constraints, the proposition here is broad.

### List some recommended sources for students to begin their research

- Mourouzis, Alexandros, et al. "An accessible and usable soft keyboard." *International Conference on Universal Access in Human-Computer Interaction*. Springer, Berlin, Heidelberg, 2007.
- Paterson III, Hugh. "Keyboard layouts: Lessons from the Me'phaa and Sochiapam Chinantec designs." Endangered languages and new technologies (2015): 49-66.
- Qin, Ryan, et al. "Optimal-t9: An optimized t9-like keyboard for small touchscreen devices." Proceedings of the 2018 ACM International Conference on Interactive Surfaces and Spaces. 2018.
- Xu, Zheer, et al. "TipText: eyes-free text entry on a fingertip keyboard." Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology. 2019.

### What would the final product look like?

You should focus on a design proposition that evaluates the quality attribute of conventional systems and proposes a solution that provides either some novelty or utility. This could be reconsidering the interaction modalities (e.g. augmenting interactions through gestures, speech, redesigning layouts.) Your solution should identify key use cases and show some empirical evidence to suggest that the new proposition has value in at least one of these domains.

It will have the following features:

- Basic alphanumeric input.
- Some expressive input modalities e.g. swiping/gestures, gaze-based input, some machine learning counterpart for learning input and reducing errors etc.
- Be usable to a pre-defined group of people. You may choose to focus on a broad market or a more specific group of people with specific accessibility/input requirements.

- The solution should consider the context of input and be adaptive in some contexts.
- There should be some empirical value to show that the solution works better than some existing solutions in the design capacity you have chosen to focus on.

It will have the following technical constraints:

- The application should be accessible to at least a pre-defined group of people.
    - You will have to consider input (e.g. multitouch, sensitivity, button sizes.)
    - The application should be capable of encapsulating input in the form of data.
    - The application should be capable of being used on at least one of the large mobile platforms such as iOS or Android.

The application should have at least a minimal viable product e.g. supporting input of upper and lowercase English characters and numbers.

## What would a prototype look like?

Your prototyping process should be robust and iterative, identifying the value of your proposition at each phase of design. This will include, as a bare minimum, phases on low, medium and high-fidelity prototyping. Changes should be based on metrics such as user feedback, market research and actionable propositions for improvement of some user-experience features.

## What kinds of techniques/processes are relevant to this project?
- Iterative development
- Prototyping and user feedback
- User interface design

## What would the output of these techniques/processes look like?
- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from your own usability tests or from external resources e.g. journal papers and conference proceedings.
- Convergence on designs that are supported by empirical evidence.
- Input modalities that encapsulate the best features of existing research, plus new findings based on prototyping and iterative evaluation.

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)? What criteria are important?
User feedback, research and functionality testing will all play a role in supporting the development of the project. The application should support, as a bare minimum, the core facets of usability practice. Namely: effectiveness, efficiency, user-satisfaction. You may wish to focus on broader accessibility goals through techniques such as scenario-based design.

For this brief, what would a **minimum pass** (e.g. 3<sup>rd</sup>) student project look like?

- Basic input modalities (e.g. letters, numbers.)
- Some attempt to design a usable interface.
- Some attempt to encapsulate research findings and/or metric driven-design.
- The report reflects on an iterative set of practices to design and develop the application.

For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

- Application functions well with limited bugs.
- The interface is successful in some metric-driven capacity.
- The design is somewhat pleasant.
- The application considers aspects of usability.
- The report evidences a rich, analytical process of design and development, highlighting both the technical challenges and user-centred design practices to underpin the work.

For this brief, what would an **outstanding** (e.g. 1<sup>st</sup>) student project look like?

- A novel proposition. This could for example involve taking the best features of existing practice and embedding them in your chosen design paradigm.
- Input for complex modalities e.g. in low light conditions, under temporary or long-term accessibility conditions, usable without requiring visual attention etc.
- Written report has excellent and concise writing style. Research and influences behind the project are clear and detailed, with extensive analysis of background works. There should be some capacity for critical evaluation here.
- The iterative design exercises utilise a range of resources to make decisions, encapsulating feedback from communities of users, user testing and scientific literature in a rigorous and considered way.
- The application is fit for purpose and extends in one area of excellence: technical merit, design, accessibility. Examples might include utilising a conversational UI, the utilisation of machine learning to provide predictions and analyses or adapting interfaces for expressive input types that might be situationally relevant.

## Project Idea Title 2: Introducing novices to strength

### What problem is this project solving?

An application (mobile or web-based) to support a novice linear progression for amateur strength or fitness training.

### What is the background and context to the question above in 150 words or less?

A Novice Linear Progression is a program for training novice to begin a fitness programme safely and maximise gains. You can choose a sport or fitness exercise of your preference, and choose appropriate goals. For example, if you were to choose weightlifting an aim could be for novice weightlifters to lift weights safely, efficiently and to maximise gains. The core concept is to teach basic barbell movements. Mark Rippetoe has published a number of books and articles on the subject. Examples of programs include Starting Strength 3x5 and Stronglifts 5x5.

### List some recommended sources for students to begin their research

Choose appropriate readings about the area of fitness you have chosen, for example, for weight lifting these are suitable examples:

- The Starting Strength website - https://startingstrength.com/
- The Stronglifts 5x5 program - https://stronglifts.com/5x5/
- The NLP - https://barbell-logic.com/why-novice-linear-progression/
- The Starting Strength Forums - https://startingstrength.com/resources/forum/

### What would the final product look like?

The final product will be a fully functional application to support people on a training progressions in your chosen exercise. It will support novices in learning and engaging in at least the three basic components of the fitness programme, for example for barbell lifting: The deadlift, the squat and the press. Additional lifts may be included at the developer's discretion and based on research around practical aspects of programming for training volume and intensity.

It will have the following features:

- The ability to track workouts across sessions.
- The ability to access resources to support learning and improving technique.
- Advice about exercises to perform per-session, training schedules and expectations for future sessions.
- Support when warming up and calculating weight distribution for each lift up to a working set.
- Advice on what to do based on certain input values (e.g. successful lifts vs failure.)

It will have the following technical constraints:

- The application should be accessible to a wide variety of users (all novices) and use-cases.
  - You will have to consider input (e.g. multitouch, sensitivity, button sizes.)
  - The application should visualise information in a clear and succinct way
  - The application should be capable of tracking and retrieving data from multiple sessions.

The application should utilise a sensible technology stack that supports data collection, retrieval and visualisation over a sustained period e.g. six weeks minimum.

There are many applications that support these types of workouts and tracking activities. That not withstanding, your application should both build on the functionality of these applications while extending in some domain of your choosing. As an example you might want to encapsulate your understanding of data from strength training communities to offer alternative designs and activity tracking that is user-centric in nature.

## What would a prototype look like?

A basic app that teaches a single exercise. The graphics or appearance do not need to be fleshed out at this stage.

## What kinds of techniques/processes are relevant to this project?
- Iterative development
- Prototyping and user feedback
- Data structures and visualisations

## What would the output of these techniques/processes look like?
- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from your own usability tests or from external resources e.g. forum posts, subreddits, interviews.
- Convergence on designs that are supported by empirical evidence.
- A way to store and retrieve meaningful data for contextually driven activities that enables critical reflection and action paths that the user might wish to take.

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)? What criteria are important?
User feedback, research and functionality testing will all play a role in supporting the development of the project. The application should support, as a bare minimum, the core facets of usability practice. Namely: effectiveness, efficiency, user-satisfaction.

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?
- The application is able to store and retrieve data in some format.
- There is an attempt to present some visual elements on screen.

- There is some evidence of historical records of data.
- The report reflects on an iterative set of practices to design and develop the application.

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

- Application functions well with limited bugs.
- The visuals provide meaningful, useful information for reflection.
- The application provides sensible guidelines for progression in line with some novice linear progression programming.
- The application considers aspects of usability.
- The report evidences a rich, analytical process of design and development, highlighting both the technical challenges and user-centred design practices to underpin the work.

## For this brief, what would an **outstanding** (e.g. 1st) student project look like?

- Visually pleasant with a user interface that is consistent in design.
- A series of interactive possibilities to support different modalities of training, types of lifts and contextually-relevant advice in relation to the user's state.
- Evidence that collection of data over time adds value, by providing insightful analytics and advice to support successful programming.
- Written report has excellent and concise writing style. Research and influences behind the project are clear and detailed, with extensive analysis of background works.
- The iterative design exercises utilise a range of resources to make decisions, encapsulating feedback from communities of users, user testing and scientific literature in a rigorous and considered way.
- The application is fit for purpose and extends in one area of excellence: technical merit, design, accessibility. Examples might include utilising a conversational UI, the utilisation of machine learning to provide predictions and analyses or creating rich overlays of data such as augmented or mixed reality.

# CM3050 Mobile Development

## Project Idea Title 1: Task manager mobile app

### What problem is this project solving?

An application that provides a simple way of logging a series of tasks to complete. Presenting them alongside the necessary information required complete them such as notes, attachments, calendar information, and the timeframe in which it is required to do complete them.

### What is the background and context to the question above in 150 words or less?

As our preference digital events management increases, while traditional forms are gradually deprecated we are presented with increasing opportunity to use mobile applications to help manage our daily workflow. To date, few mobile applications manage to well-present data from a wide-range of sources in a simple, accessible format.

### List some recommended sources for students to begin their research

- Background research: PC Mag best to-do list apps: https://uk.pcmag.com/productivity-2/90672/the-best-to-do-list-apps-for-2020
  - Firstly, look at the current apps on the market, what do they all do well? Are there discrepancies between apps? What features could you include that would differentiate your application from others?
- Game-ification of task management apps: https://hcigames.com/wp-content/uploads/2015/01/Deconstructing-Gamified-Task-Management-Applications.pdf
  - Understand the various approaches to creating task management apps, including producing 'gamified' incentives to complete tasks
- What a to-do: studies of task management towards the design of a personal task list manager
  https://www.academia.edu/4323375/What_a_to_do_studies_of_task_management_towards_the_design_of_a_personal_task_list_manager?auto=citations&from=cover_page
  - Study what elements and formats best suit task management apps, including which are best for overall productivity

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final production should be a fully functioning mobile application that allows users to input a series of different tasks to complete. Your app should include the functionality to mark these items as 'completed'.

You should integrate multiple forms of connectivity to useful tools and apis, possible including calendar integration, weather prediction apis, time predictions etc.

You could even combine productivity data with machine learning to analyse working habits and suggest timeframes for completion.

At least, it should be simple, easy and reliable to use. With a clearly thought through user interface with appropriate and accessible styling throughout. It should be responsive and work for a wide-range of devices.

## What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What IS important to make clear?*
*What is NOT important at this stage?*

A simple prototype should include basic functionality so that you can easily demonstrate the purpose of the application.

This would include the ability to add tasks, mark them as done, add and edit timeframes. Additional features including calendar intergration might be mocked up and implemented at a later stage.

You should be able to test the complete user flow to check for usability issues.

## What kinds of techniques/processes are relevant to this project?
- User flow diagrams
- Wireframing
- Iterative development
- User testing
- Unit testing
- React Native development is highly suggested

## What would the output of these techniques/processes look like?
- Fully completed user flow diagrams demonstrated the expected user flow between multiple pages. Including breakdowns of key actions and events, such as adding items to the list, altering them and marking them as complete.
- Wireframe diagrams at mid to high fidelity, demonstrating the planned layout and UI of the application.
- Continual testing on potential users, collecting feedback and making appropriate changes to the application.
- A series of well-built unit tests to check both the logic and UI of the mobile application.

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)?

## What criteria are important?

Students should gather iterative feedback from potential uses throughout the entire development stage. This feedback should be collated and acted upon accordingly.

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?
- A basic application that allows some form of tasks to be inputted and stored on the system.

- The application lacks significant organisation-focused features, including timeframe suggestions or tracking.
- The written report mentions basic elements of testing that were collected during development, yet fails to outline how these had an impact on the final application.
- Little to no use of user-flow diagrams or wireframes

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

- An application that provides the ability to add tasks and see them alongside organisation-based tools and suggestions including timeframe suggestions or calendar integration.
- The application used user-testing to carefully select integration with third party services, and this is evident in the written report.
- Clear link between feedback and development progress, backed up with altered wireframing or user flow diagrams.
- A confident application that could be used in day-to-day scenarios

## For this brief, what would an **outstanding** (e.g. 1st) student project look like?

- An application that has clearly been developed as a result of extensive market analysis and research with articles and papers cited alongside key decisions made, documented in the written report.
- Clear and concise user testing throughout development, aided by wireframing and associated techniques.
- Production ready product that could be submitted to an app store.

## Project Idea Title 2: Word-based game

### What problem is this project solving?

A fun, word-based game that can be played on any mobile device. The game should use finding words as the core game mechanic and should aim to be a casual game, that is often played in short sporadic opportunities, such as while on a train.

### What is the background and context to the question above in 150 words or less?

People often look for short, simplistic but addictive games to play at opportune moments, such as while on public transport. These games often have a simple-to-grasp core concept and game mechanic and are repetitive in nature. Often, these games take inspiration from older, more traditional games, such as wordsearches or noughts and crosses/tic-tac-toe.

### List some recommended sources for students to begin their research

- Spell tower, a simple addictive word-based game: http://www.spelltower.com
  - Understand the approaches that other developers have taken, what works well? What could you improve upon?
- The effect of games and simulations on higher education: a systematic literature review https://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-017-0062-1
  - Perhaps your game could have an educational-focus, what elements of games best encourage education?
- Thoughts on Designing Word-Building Games https://medium.com/@robin.david/thoughts-on-designing-word-building-games-f530792a46e1
  - A developers thoughts on creating word games after a successful kickstarter *Movable Type*

### What would the final product look like?

*(e.g. presentation, usability, functionality, results)?*

The final product should be a fully functional word-based game that uses a fun, unique game mechanic to create short, addictive gameplay. This application should store high-scores and allow the user to compete against themselves.

The game should work across multiple screen types and adapt for device-specific requirements such as notches.

The interface should be simple, and intuitive. With carefully selected design, that is both appropriate and accessible throughout.

### What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A prototype should demonstrate the basic functionality, so that you can demonstrate the gameplay.

This would include the ability to engage with the game and score points. The design and visuals might not be fully realised at this point, so may use placeholders.

The full game mechanic should be functional so that you can test it out on users and receive detailed feedback, in regards to how fun the game is, and whether you could make any improvements.

## What kinds of techniques/processes are relevant to this project?
- User flow diagrams
- Wireframing
- Iterative development
- User testing
- Unit testing
- React Native development is highly suggested

## What would the output of these techniques/processes look like?
- Fully completed user flow diagrams demonstrated the expected user flow between multiple pages/screens. Including breakdowns of key events, such as interacting with game elements, and fail/success screens.
- Wireframe diagrams at mid to high fidelity, demonstrating the planned layout and UI of the application.
- Continual testing on potential users, collecting feedback and making appropriate changes to the application.
- A series of well-built unit tests to check both the logic and UI of the mobile application.

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)?
### What criteria are important?
Students should gather iterative feedback from potential uses throughout the entire development stage. This feedback should be collated and acted upon accordingly.

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?
- A basic application that uses a familiar game mechanic to create a word-based mobile game, which takes user interaction and allows them to participate in the game.
- The game functions, however is less-thought through and does not clearly resemble a fully developed and iterated design.
- Little to no evidence of user testing is present in the app or the written report.
- A user is unlikely to spent significant time enjoying this application.
- The game might feel similar to other game mechanics and potentially derivative.

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?
- The game is fun to interact with and at its core contains a simple but effective word-based game mechanic.

- The game mechanic shows signs of continued improvement, with user-testing based development, noted in the written report.
- Wireframes, design concepts and user flow diagrams aided the development process and show true evolution from concept to reality.
- The game is fun, and with small improvements could be production ready.

For this brief, what would an **outstanding** (e.g. 1st) student project look like?
- The game is impressive, with a clever, well thought through mechanic which is different from notable applications
- Your development process is well documented and aids our understanding of the application.
- It is clear that your feedback had a meaningful impact on the development process, including the final product.
- Your application is ready for publication, and could be submitted to the app store with little to no amendments.

# CM3015 Machine Learning and Neural Networks

## Project Idea Title 1: Deep Learning on a public dataset

### What problem is this project solving?

Choosing, based on a quantitative evaluation, a well performing machine learning model for used with a publicly available dataset.

### What is the background and context to the question above in 150 words or less?

Pick a dataset from Kaggle.com – choose one that interests you or you think is important – for example: tweets, faces, lung scans, skin diseases, student grades…

Develop a deep learning classificatation/regression model for your chosen dataset by following the methodology of Deep Learning with Python. Aim to find the best model – work from simple to deep and employ the advanced techniques of Chapter 7.

### List some recommended sources for students to begin their research

- F.Chollet, Deep Learning with Python, 1st ed.
- Kaggle.com

### What would the final product look like?

*(e.g. presentation, usability, functionality, results)?*

A research project – the final product is a report

### What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

The prototype is a baseline model that achieves a common sense prediction.

It is not important to achieve the accuracy of any puplished paper on this dataset (or any of the Kaggle public notebooks)

### What kinds of techniques/processes are relevant to this project?

Jupyter notebooks

Tensorflow, matplotlib and associated Python libraries

## What would the output of these techniques/processes look like?

Model code

Validation plots

Prediction on test set

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?

## What criteria are important?

Does the model significantly improve on a commonsense baseline

Have I investigated all the alternatives

## For this brief, what would a **minimum pass** (e.g. 3<sup>rd</sup>) student project look like?

- Any original model that runs and produces a prediction
- A basic evaluation of the model on the public dataset
- Report is well-strutured

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

In addition to minimum pass criteria:

- A sequence of orginal models of increasing depth and sophistication
- An evaluation of the different models using the public dataset, which makes it possible to draw conclusions about the effectiveness of different models and choose a preferred model
- Report: Correct application of the DL methodology; good standard of written, technical English

## For this brief, what would an **outstanding** (e.g. 1<sup>st</sup>) student project look like?

In addition to the good criteria:

- Replication of a hight quality published model(s) on the chosen dataset
- An evaluation of the models to the standard of academic research
- The report is a self-contained explanation and account of theory and experiment. There is a literature review and the work is contextualised. Critical comparison of best model and re-implemented model(s) and results in the literature.

## Project Idea Title 2: Gather your own dataset

### What problem is this project solving?

Gathering a data set and training a model to develop a classification system

### What is the background and context to the question above in 150 words or less?

Most practical machine learning involves gathering data, labelling it and using it to train a machine learning model. The data gathering challenge as it is important to gather data that is representative of real world data and that distinguishes well between the different classes. Contemporary Deep Learning techniques often need huge datasets, into the 10s or 100s of thousands of items, which would not be feasible for this kind of project. But it is possible to build on pre-trained datasets which can be used as features extractors. The aim of this project is to gather a dataset of a moderate size (100s), including both training and testing sets. We recommend a dataset of images as there are plenty of good pre-trained models. You can either generate the dataset yourself (taking images or video) or curate existing unlabelled images. You should label the images and train a machine learning model, based on a pre-trained model, on the dataset. You should try a number of variant models, from simple to complex and using different pre-trained models if they exist, and compare the results. Iterative development should include both improvements to the model and dataset.

### List some recommended sources for students to begin their research

- F.Chollet, Deep Learning with Python, 1$^{st}$ ed. Section 5.3 discusses how to use pretrained models
- Model Zoo is a good source of pre-trained models https://modelzoo.co/category/computer-vision

### What would the final product look like?

*(e.g. presentation, usability, functionality, results)?*

A dataset (a collection of labelled images, or similar data), and code for training a model. The main output would be a report showing results of the data.

### What would a prototype look like?

*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

The prototype is a small version of the dataset, tested on a simple baseline model. It needs to show that it is possible to train a basic model on the types of data needed. It needs to ensure that the data is in a suitable format for machine learning and that it works with the machine learning platform being used.

It does not have to show accurate classification at this state.

## What kinds of techniques/processes are relevant to this project?
Basic image storage and editing. Data labelling.

Jupyter notebooks

Tensorflow, matplotlib and associated Python libraries

Pretrained models

## What would the output of these techniques/processes look like?
A dataset (e.g. images stored in a suitable format and folder structure)

Model code

Validation plots

Prediction on test set

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)?
## What criteria are important?
Does the model significantly improve on a commonsense baseline

Have I investigated all the alternatives

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?
- A basic data set gathered
- Using the data to train on pre-trained model with some minimal training.
- Basic evaluation metrics on the result
- Report is well-strutured

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?
In addition to minimum pass criteria:

- A well curated dataset that is suitable for training a machine learning model
- The data set covers a good range of possible variants of each class
- A well chosen pre-trained models used as the basis of a series of full machine learning models used to train on the dataset
- A thorough evaluation of the different models
- Report: Correct application of the DL methodology; good standard of written, technical English

For this brief, what would an **outstanding** (e.g. 1ˢᵗ) student project look like?

In addition to the good criteria:

- A novel idea for a data set
- Very good coverage of different variants of each class
- A number of well designed machine learning models culminating in a complex but appropriate model
- An evaluation of the models to the standard of academic research
- The report is a self-contained explanation and account of theory and experiment. There is a literature review and the work is contextualised. Critical comparison of best model and re-implemented model(s) and results in the literature.

# CM3040: Physical Computing and Internet of Things

## Project Idea Title 1: Privacy-Preserving Virtual Avatar & Smart Environment Visualisation for Assistive Living System

### What problem is this project solving?
How can we give control to user's privacy within assisted living systems where diverse discriminative sensing methods are deployed?

### What is the background and context to the question above in 150 words or less?

Assisted living systems are being developed for the elderly, professional health services and even for their family members and relatives to monitor, provide efficient care and support for the elderly when required non-intrusively.

In general, assisted living systems collects data using appropriate smart Internet-of-things (IoT) devices/sensors, analyse the data to recognising the daily activities being performed by the inhabitant in a given room and prompt them if required.

The goal of the project is not to recognise their daily activities but to simulate the person's actions in a given virtual room with an virtual avatar of a person from the sensors data log. You can think of this virtual simulation of home environment and virtual avatar as the strategic game The Sims: FreePlay game.

The sensors data log will have information about what object they are interacting with, when are they doing it and how are they interacting with it. You can create your own data log to simulate the actions and move the avatar in the virtual space or use existing real datasets available online for human activity recognition. You can refer to some of the papers reference below to get some idea of types of data generated from smart home environment and why assisted living systems are required.

This virtualisation of the events of a person help annoyomising and preserving individual's privacy and integrity when their information is shared with other person for monitoring and care purposes.

In this project, you will also perform a literature review in different sensing approaches, analyse their data and decide how to best represent this data using a 2D/3D map of the room with sensors attached (i.e., smart environment) to objects with a virtual avatar to depict the events occurring.

A variation of this project could be that you allow users to choose their own avatar, have more than one residents interacting with objects in the different room of the home environment at the same time.

### List some recommended sources for students to begin their research

- S. Deep, X. Zheng, C. Karmakar, D. Yu, L. G. C. Hamey and J. Jin, "A Survey on Anomalous Behavior Detection for Elderly Care Using Dense-Sensing Networks," in IEEE Communications Surveys & Tutorials, vol. 22, no. 1, pp. 352-370, Firstquarter 2020, doi: 10.1109/COMST.2019.2948204.

- D. Triboan, A. Meggi, "[A Personalised Virtual Smart Home Space Representation to Preserve User's Privacy and Integrity in The Assisted Living System within the context of Diu Island](#)", Digitizing Safety, Health & Wellbeing, Urban Assemblage: The City as Architecture, Media, AI and Big Data, University of Hertfordshire, 28-30 June 2021.
- S. Fallmann, I. Psychoula, L. Chen, F. Chen, J. Doyley, D. Triboan, "Reality and Perception: Activity monitoring and data collection within a real-world smart home", 2017 IEEE Ubiquitous Intelligence and Computing (UIC), San Francisco, CA, USA, August 4-8, 2017.
- D. Triboan, A. Meggi, "Reformulating a Smart Home System for the Indian Context: Diu Island", International Journal of Design & Nature and Ecodynamics, WIT PRESS, 2019.

## What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

Expected Deliverables

A dissertation report and system prototype with documentation covering the following aspects:

• Report: introduction/methodologies adopted, literature review in and around the project topic to identify limitations in existing knowledge, proposed approach, prototype implementation details, evaluation and conclusion/research direction.

• Prototype: Android application/Website GUI design with 2D/3D model simulating sensor events and potential activates occurring.

## What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A basic Android or web GUI that interacts with a simulation, to prove the basic interaction and the fact that the two elements can communicate together.

Neither needs more that very bare bones functionality and neither need to be polished at this stage.

## What kinds of techniques/processes are relevant to this project?
Basic programming skills in a preferred programming language.

Some exposure to developing Web Service/Website, Mobile application and programming to display graphical model of the room within the application would be beneficial.

## What would the output of these techniques/processes look like?
- Web services API development for providing sensor data stream simulation, user authentication/authorisation, data storage and policy management.
- Mobile application/ Website development with suitable libraries to visualise diverse sensor data and interactive 2D/3D messages.

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?

By the mid-term of the project, you will be evaluated on how you have introduced the project, aims and object and discuss what methodology you have adapted to conduct the literature review on this topic. The methodology should include what software development development life cycle is adated, project management plans (such as Gantt chart, risk assessement, identifiying resources required) and the scope of the project. Based on the findings, you will have proposed and identified key functional and non-functional requirements of your system and created a system implemantion design plans (i.e., use case diagrams, class diagrams, user interface plans, and testing statergies). It is expected that some progress of system development is made and highlighted in the report but your not expect to submit any code at this stage.

For the final submission of the project, you will be expected to complete and develop the functional and non-functional requirements of your system with details and justifications of the tools and techniques used to develop the system. A full testing report of each requriements based on stratergy described in the mid-term report is required to show if they pass the tests or not. A critical reflection of the overall project and conclusion should be included in the final report also.

In essense, the you will be evaluated on the report containing the key items described above and your system prototype in terms of robustness of implementation, code documentations, suffcent number of features and complexity of the implemention.

## What criteria are important?

Report (mid-term)

- Contexualisation of the problem context for preserving privacy and integrity of a person being monitored remotely.
- Literature review on studies carried out in this area of how assisted living system are developed, why privacy is a problems, what is being done about it and highlighting how your system would enrich it or do something differently.
- Proposal of overall system architecture where different users/stakeholders can connect to your system to view 2D/3D simulatin of user actions in the environment regardless of their operating system.
- System design plan (including functional/ non-functional requirements)
- Any implementation progress

Report + System Prototype (final)

- System implementation details and justification
- System testing
- Critical reflection
- Conclusion/future work

## For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?

- Report: should cover problem statements, aims & objectives, *basic* literature and understanding of the topic, proposed system requirements/architecture, design plan, implementation and testing of key features.

- Prototype: 2D/3D Avatar within a home environment is developed with the ability to programmatically control the avatar based on sensor log.

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

- Report: should cover problem statements, aims & objectives, adequate literature and understanding of the topic (including technical challenges), proposed system requirements/architecture, detailed design plan, implementation and testing of key features.
- Prototype: 2D/3D simulation of the home environment based on sensor log with the ability to login and customise avatar. Most key features if not all are tested rigorously using a suitable testing strategy.

## For this brief, what would an **outstanding** (e.g. 1st) student project look like?

- Report: should cover problem statements, aims & objectives, comprehensive literature and critical reflection to show the understanding of the topic (including technical challenges), proposed system requirements, develop suitable system architecture, create a detailed design plan, implementation evidence and testing of key features.
- Prototype: In addition to 2D/3D simulation of events for one resident, more complexities and control features are integerated such multi-residents interacting with objects based on sensor log files, and all key features implemented and tested rigorously using a suitable testing strategy.

## Project Idea Title 2: A Low-cost Wild Animal and Intrusion Detection system for Assisted Living System in Rural Area

### What problem is this project solving?
How to develop a low-cost, energy-efficient and limited or no internet access for an Internet-of-Things (IoT) based Assisted system?

### What is the background and context to the question above in 150 words or less?
The assisted living systems are typical used by non-technical expert users and configure/maintaining Internet-of-Things(IoT) devices to the system is a biggest challenge. Moreover, assisted living systems in rural area with limited internet access, low-income community and elderly populations live in fears of wild animals entering the property or their house broken into.

Internet-of-Things (IoT) devices are typically developed to sense the environment such as temperature and humidity and transmit the data over internet to a remote cloud server to analyse and store the data. The cloud server can then create automation or trigger events such as turning light or fan on/off if is too dark or to hot/cold. (This process is known as cloud computing paradigm.) However, is it possible to delegate some of these automation responsibilities to the (edge) devices closer to the sensing devices to lower network traffic and computation load on the server? (This process is known as edge computing paradigm.) Moreover, wireless IoT devices typically run on battery, is it possible to develop devices that runs longer or self-charge?

In this project, you will be expected to explore developing and working with physical IoT devices that you must identify and acquire yourself to create a small network of IoT devices with sensors that is low cost, uses low energy or self charges and does not rely on internet to function or create automation tasks. Support will be provided by the supervisor regardless of your experience in working with the physical IoT devices.

A variation of the project can be to use develop an wild animal detection or intrusion detection system using IoT devices (i.e., ESP32 mircontroller) with low-energy consumption/self-charging and little to no internet connection (see https://www.tensorflow.org/lite for more information).

### List some recommended sources for students to begin their research
- D. Triboan, A. Meggi, "Reformulating a Smart Home System for the Indian Context: Diu Island", International Journal of Design & Nature and Ecodynamics, WIT PRESS, 2019.
- Digitizing Safety, Health & Wellbeing, Urban Assemblage: The City as Architecture, Media, AI and Big Data, University of Hertfordshire, 28-30 June 2021.
- S. Fallmann, I. Psychoula, L. Chen, F. Chen, J. Doyley, D. Triboan, "Reality and Perception: Activity monitoring and data collection within a real-world smart home", 2017 IEEE Ubiquitous Intelligence and Computing (UIC), San Francisco, CA, USA, August 4-8, 2017.

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

Expected Deliverables

A dissertation report and system prototype with documentation covering the following aspects:

• Report: Introduction/methodologies adopted, literature review in and around the project topic to identify limitations in existing knowledge, proposed approach, prototype implementation details, evaluation and conclusion/research direction.

• Prototype: An ESP32 microcontroller or similar IoT devices (with a camera prototype?) to recognise wild animals and anomalies without the need for a constant internet connection. In addition, supporting mobile applications/websites should be developed to allow owners to view live data and configure where personal data will be saved and processed.

The IoT and AI-based microcontroller with a camera and other suitable sensors will need to be sourced by the candidate carrying out this project. An existing image recognition platform can be utilised such as TensorFlow Lite to allow rapid prototyping and creating a low cost, and internet low connectivity and energy-efficient device.

The exterior of the device can be packaged up as a potential commercial product but it's NOT as important at this stage.

However, this prototype will need to be able to detect intrusion from wild animals and people either on the IoT microcontroller by itself or another device locally deployed on the same network such as raspberry PI.

The notification can be in the form of buzzer sound, LEDs blinking or haptic feedback based on the user's location, i.e. if the user is in the kitchen, then a notification device located in the kitchen should react to alert the user. The selection of notification method can be determined by the user's medical information at the setup, i.e., if they have lower hearing or visual impairments.


## What would a prototype look like?
*What would it show?*
*What does it need to prove?*
*What **IS** important to make clear?*
*What is **NOT** important at this stage?*

A basic microcontroller hooked up to a camera and other sensors. A very basic image recognition software set up.

At this stage it does not need to be accurate enough to detect animals (that comes later), just detecting the presence or absence of movement or objects to test the basic interaction between the camera, microcontroller and computer vision.


## What kinds of techniques/processes are relevant to this project?
Basic programming skills in a preferred programming language (i.e., C/ Python for microcontrollers).

Some exposure to working with a microcontroller, Web Service/Website, Mobile application and programming to display data within the application would be beneficial.

- A prototype with ESP32, Arduino MKR IOT based microcontroller or similar with the camera to detect animals and people for intrusion detection and alerting. (Please note, for testing purposes, you can use printed images or other simulation methods.)
- Web services API development for receiving a sensor data stream, user authentication/authorisation, data storage and policy management.
- Mobile application/ Website development to allow the user to interact with web services API to consume and set up hybrid, cloud or edge only mode.
- A report containing literature review, design architecture, implementation plan and evaluation of the prototype.

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)?

By the mid-term of the project, you will be evaluated on how you have introduced the project, aims and object and discuss what methodology you have adapted to conduct the literature review on this topic. The methodology should include what software development development life cycle is adated, project management plans (such as Gantt chart, risk assessement, identifiying resources required) and the scope of the project. Based on the findings, you will have proposed and identified key functional and non-functional requirements of your system and created a system implemantion design plans (i.e., use case diagrams, class diagrams, user interface plans, and testing statergies). The proposal needs to include atleast 3 microcontrollers and suitable sensors to detect animals and unknown human beings, analyse/store data and sends notifications to the residents appropriately. It is expected that some progress of system development is made and highlighted in the report but your not expect to submit any code at this stage.

For the final submission of the project, you will be expected to complete and develop the functional and non-functional requirements of your system with details and justifications of the tools and techniques used to develop the system. A full testing report of each requriements based on stratergy described in the mid-term report is required to show if they pass the tests or not. A critical reflection of the overall project and conclusion should be included in the final report also.

In essense, the you will be evaluated on the report containing the key items described above and your system prototype in terms of robustness of implementation, code documentations, suffcent number of features and complexity of the implemention.

## What criteria are important?

Report (mid-term)

- Contexualisation of the problem context for creating decentralised assisted living systems at low-costs, low-energy and with limited internet connectivity.
- Literature review on studies carried out in this area of how assisted living system are developed, why decentralised system is required, what is being done about it and highlighting how your IoT system would enrich it or do something differently.
- Proposal of overall system architecture (software and hardware level) where different devices interact with each other and description of their role.
- System Design plan (including functional/ non-functional requirements)
- Any implementation progress

Report + System Prototype (final)

- System Implementation details and justification of selection of hardware and software components, User interface etc.
- System Testing
- Critical reflection of the overall project.
- Conclusion/future work

## For this brief, what would a **minimum pass** (e.g. 3ʳᵈ) student project look like?

- Report: should cover problem statements, aims & objectives, *basic* literature and understanding of the topic, proposed system requirements/architecture, design plan, implementation and testing of key features.
- Prototype: limited wild animal or unauthorised users detected on the premisis but does not communicate with other IoT devices to create automations (i.e., alerting inhabitant).

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

- Report: should cover problem statements, aims & objectives, adequate literature and understanding of the topic (including technical challenges), proposed system requirements/architecture, detailed design plan, implementation and testing of key features.
- Prototype: Atleast 3 microcontrollers utilised for developing to recognise unknown person or wild animals and sending appropriate notification to users. Some attempts made to lower the energy consumption or self-charging capabilities for minimal maintaince effort required by non-technical users. A reasonable efforts made for testing the system.

## For this brief, what would an **outstanding** (e.g. 1ˢᵗ) student project look like?

- Report: should cover problem statements, aims & objectives, comprehensive literature and critical reflection to show the understanding of the topic (including technical challenges), proposed system requirements, develop suitable system architecture, create a detailed design plan, implementation evidence and testing of key features.
- Prototype: 3 or more microcontrollers used with multiple sensing and resident notification methods to alert them adequately. All key features identified implemented and tested rigorously using a suitable testing strategy.

## CM3025 Virtual Reality

## Project Idea Title 1: VR Game

### What problem is this project solving?

Create a virtual reality game that makes full use of VR interaction techniques and in particular full body interaction.

### What is the background and context to the question above in 150 words or less?

Video games are currently the biggest consumer application of Virtual Reality and VR has the potential to transform how we play games both by making them more immersive and by allowing us to interact with our whole bodies. The game in this project should draw on your knowledge of both VR and game development modules, and should make full use of the potential of VR interaction techniques (not just a straight port of a non-immersive game)

### List some recommended sources for students to begin their research

- Online store fronts such as Steam, the Oculus Store and VIVEPort are the best places to find interesting VR games and experiences for inspiration.
- Beat Saber, Half-life Alyx, SuperHot, and Job Simulator are some examples of the diversity of gameplay and style that is possible in VR.
- 3D User Interfaces: Theory and Practice by Bowman et al. is a very good starting point for VR interaction techniques
- The IEEE VR, Virtual Reality Software and Technology (VRST), ACM SIGGRAPH and GDC conference proceedings are an excellent source of cutting edge techniques

### What would the final product look like?
*(e.g. presentation, usability, functionality, results)?*

The final product will be a fully functional video game that would be suitable for play using a VR HMD

It will have the following game design characteristics:

- Uses the full body as part of interaction
- Includes a suitable VR navigation technique
- Makes use of, and shows of the unique features of VR (it would not work as a screen based game)
- Does not cause significant nausea or discomfort

### What would a prototype look like?
*(What would it show? What does it need to prove? What **IS** important to make clear? What is **NOT** important at this stage?)*

Prototype needs to show a core gameplay loop which is challenging, engaging, simple to pick up but which shows strong promise for emergent complexity. It needs to prove you know what the core of your game is, what the player is meant to be doing and how they are going to do it.

Most mechanics and broad aspects of level design should be clear at prototype stage. Graphics and sound are not important at this stage. Prototype is perfectly fine using boxes and other primitive objects.

## What kinds of techniques/processes are relevant to this project?

- Iterative development
- Frequent playtesting
- VR Interaction design
- Unity/C#.

## What would the output of these techniques/processes look like?

- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from play testers.
- Some aspects of the game have been dropped from the first iterations, some have been added, some have been modified, in line with AGILE development practices.
- Several sets of feedback from players that inform your ongoing development and design process.

## How will this project be evaluated and assessed by the student (i.e. during iteration of the project)? What criteria are important?

Student will use play testers and solicit feedback on the developing game. Main source of data will be player opinions and, where possible, player actions where it's possible to directly observe playtesting. Students should also use standard metrics such as the Simulator Sickness Questionnaire and a presence questionnaire to assess how well it works in VR).

## For this brief, what would a minimum pass (e.g. 3rd) student project look like?

- Game can be loaded, started and finished without major bugs/crashes.
- The game works in VR, but is not designed to make full use of the features of the medium, it might be a too literal port of a standard screen-based game
- The game does not generate high levels of presence and/or generates some nausea or discomfort
- Poor audio-visual presentation.
- Gameplay is confusing and/or boring.
- Written report lacks research, detail of process, issues encountered in production, and/or doesn't name influences or audio-visual assets used appropriately.

## For this brief, what would a good (e.g. 2:2 – 2:1) student project look like?

- Game functions well without bugs.
- The gameplay and interaction is well designed for VR and shows off the best features of VR (it would not work in other media)
- The game does not cause discomfort in most people and scores well for presence

- Good audio-visual presentation.
- Gameplay is quickly understandable, it's easy to start playing.
- Written report makes clear the challenges faced and how they were overcome. Makes clear the influences that went into the game (e.g. games played and analysed, which mechanics were inspired from where etc.).
- Audio-visual assets appropriately credited.
- Playtesting feedback is clearly gathered and acted on.

## For this brief, what would an **outstanding** (e.g. 1st) student project look like?

- Game is highly-polished technically, and in terms of audio-visual presentation.
- Game uses innovative and original mechanics (or well-known mechanics in a novel manner), that really show off the potential of VR
- The game does not cause discomfort in most people and scores well for presence
- Game requires no instructions – it's very clear what the objective is and how to achieve it from the opening screen.
- Game is easy to start playing, but repeated play shows a well-selected set of simple mechanics that lead to depth and emergent complexity as the player replays the game over several sessions.
- Written report has excellent and concise writing style. Research and influences behind the project are clear and detailed, with extensive analysis of background works.
- Playtesting has been frequent/ongoing, extensive feedback has been gathered and documented and it's very clear how this has been incorporated into the iterative development of the game.
- It is evident there have been several version/iterations of the game, and the challenges at each point have been documented and analysed.

## Project Idea Title 2: VR Learning Experience

### What problem is this project solving?

Create a virtual reality experience that allows people to learn something new by directly experiencing something in a virtual world.

### What is the background and context to the question above in 150 words or less?

Virtual Reality has huge potential for learning, because it makes it possible to experience, in virtual form something that would not be possible otherwise. This could be standard academic classroom learning, for example, seeing and interacting with a virtual representation of a molecules, but learning can be much broader. It could be practicing a work task, for example assembling complex equipment or performing a medical procedure. It can include travelling to a different place or time, seeing an ocean reef or a Han dynasty Chinese village. It can include stepping into someone else's shoes, experience a different life, such as the Guardian's 6x9 experience of a solitary confinement cell or Stanford VR's Becoming Homeless. What unites all of these examples is that they are not about telling people something but about allowing them to experience it directly.

### List some recommended sources for students to begin their research

- Online store fronts such as Steam, the Oculus Store and VIVEPort are the best places to find interesting experiences for inspiration.
- Experience on Demand by Jeremy Bailenson is a great book about VR in general but experiential learning in particular
- 3D User Interfaces: Theory and Practice by Bowman et al. is a very good starting point for VR interaction techniques
- The IEEE VR, Virtual Reality Software and Technology (VRST), ACM SIGGRAPH and GDC conference proceedings are an excellent source of cutting edge techniques

### What would the final product look like?

*(e.g. presentation, usability, functionality, results)?*

The final product will be a fully functional VR experience that allows users to learn through experience. It should be 3-5 minutes of experience

It will have the following game design characteristics:

- Allows users to experience a simulation of an experience and learn from it
- It minimises explicit "telling" via voice overs or text, and should focus on learning by doing and through experience
- Includes suitable VR interaction and navigation techniques that are as close as possible to the real experience
- Makes use of, and shows of the unique features of VR (it would not work as a screen-based game)
- Does not cause significant nausea or discomfort

## What would a prototype look like?
*(What would it show? What does it need to prove? What **IS** important to make clear? What is **NOT** important at this stage?)*

Prototype needs to show a core VR interaction technique that simulates how people would interact with the experience in the real world. At the first prototype the focus should be on reproducing the experience rather than on learning yet.

## What kinds of techniques/processes are relevant to this project?
- Iterative development
- Frequent playtesting
- VR Interaction design
- Unity/C#.

## What would the output of these techniques/processes look like?
- A series of incrementally improving prototypes – showing how you have tested and incorporated feedback from play testers.
- Some aspects of the experience have been dropped from the first iterations, some have been added, some have been modified, in line with AGILE development practices.
- Several sets of feedback from participants that inform your ongoing development and design process.

## How will this project be evaluated and assessed **by the student** (i.e. during iteration of the project)? What criteria are important?
Student will use testers and solicit feedback on the developing experience. The main measure should be how well they learn. This could be done by testing before and after the experience on a tasks and see how much they improve. In some cases this could be about factual knowledge (e.g. about Han Dynasty China), in others it could be practical skills (assembling machinery) or changes in attitude (experiencing being homeless). Another source of data will be participants' opinions and, where possible, actions where it's possible to directly observe playtesting. Students should also use standard metrics such as the Simulator Sickness Questionnaire and a presence questionnaire to assess how well it works in VR.

## For this brief, what would a **minimum pass** (e.g. 3rd) student project look like?
- The experience can be loaded, started and finished without major bugs/crashes.
- The experience works in VR, but is not designed to make full use of the features of the medium. The learning might rely too much on explanation rather than direct experience.
- The experience does not generate high levels of presence and/or generates some nausea or discomfort
- The experience attempts to teach something but there is little evidence of successful learning.
- Poor audio-visual presentation.

- Gameplay is confusing and/or boring.
- Written report lacks research, detail of process, issues encountered in production, and/or doesn't name influences or audio-visual assets used appropriately.

## For this brief, what would a **good** (e.g. 2:2 – 2:1) student project look like?

- The experience functions well without bugs.
- The interaction is well designed for VR and shows off the best features of VR (it would not work in other media), and uses experiential learning
- The experience does not cause discomfort in most people and scores well for presence
- The experience has clear learning objectives, and evidence from participants that they have been achieved
- Good audio-visual presentation.
- Gameplay is quickly understandable, it's easy to start playing.
- Written report makes clear the challenges faced and how they were overcome. Makes clear the influences that went into the game (e.g. games played and analysed, which mechanics were inspired from where etc.).
- Audio-visual assets appropriately credited.
- Playtesting feedback is clearly gathered and acted on.

## For this brief, what would an **outstanding** (e.g. 1st) student project look like?

- The experience is highly-polished technically, and in terms of audio-visual presentation.
- The experience uses innovative and original VR technique to enable experiential learning)
- The experience does not cause discomfort in most people and scores well for presence
- There is strong evidence that participants have learned effectively or changed their attitude. Participant research is well conducted
- Written report has excellent and concise writing style. Research and influences behind the project are clear and detailed, with extensive analysis of background works.
- Playtesting has been frequent/ongoing, extensive feedback has been gathered and documented and it's very clear how this has been incorporated into the iterative development of the game.
- It is evident there have been several version/iterations of the experience, and the challenges at each point have been documented and analysed.