OUR RESEARCH STRATEGIES FOR 2021 AND BEYOND

Prof Fabio Cuzzolin

The Visual Artificial Intelligence Laboratory

Lab seminar, January 27 2021
Our research themes
Overview

• **Computer Vision** (deep learning for action detection, causal 3D CNNs, video captioning, future event prediction, scene understanding)

• **Machine Learning** (metric learning, continual learning, federated learning, self-supervised learning)

• **Artificial Intelligence** (machine theory of mind, epistemic AI, neuro-symbolic reasoning)

• **AI for Healthcare** (early diagnosis of dementia, Parkinson’s, audio-visual monitoring of people in a coma, empathetic AI)

• **Robotics** (surgical robotics, autonomous driving, Formula Student AI, ROAD)

• **Uncertainty Theory** (random set theory, belief functions, geometry of uncertainty, pandemic modelling)
Computer vision
Real time human action detection

- The Visual AI Lab is leader in the field, multi-year expertise, **first system able to detect multiple human actions and events in real time**
- [https://sahasuman.bitbucket.io/](https://sahasuman.bitbucket.io/)
- Won awards at both CVPR 17 Charades and ActivityNet 2016 action detection challenges
- Based on deep neural networks [BMVC’16, BMVC’18, ICCV’17x2, ACCV’18]
- Frame-level detections are linked up in real time to form **‘action tubes’**
- Still very influential work in the field, we need to pick this up
Prediction of future events

- We are now moving towards the early recognition of events and activities [ECCVW’18, ICCV’19]
- Just by observing a small fraction of the video frames we can guess what is going on there

- New machine translation approach by Mohamed
• 3D CNNs (C3D, I3D, (2+1)D) have risen to the forefront of video classification

• However, they work on entire videos as a whole in a batch manner

• We recently proposed a Recurrent Convolutional Network designed to replace the temporal convolution component with a recurrent model in the temporal dimension

• [Gurkirt Singh, ICCV’19 submission, PAMI in preparation]
From simple actions to complex activities

- Topic: **modelling complex road activities as graphs of ‘atomic’ actions/events**

- A deep network architecture is designed to detect those graphs of actions.

- When one is partially observed, **we can guess what events may take place in the future and where**

- 3-year Huawei research agreement, EU H2020 SARAS surgical robotics project

- Salman Khan’s PhD topic, plus Ajmal Shahbaz as a new research fellow

- ROI pooling pipeline, extra annotation provided to the ROAD dataset
Semantic deep video captioning

- Problem: describing videos in natural language, possibly in real time
- Personnel: Silvio Olivastri
- Extracting graphs of facts from videos
- Incorporating semantic and prior knowledge into the process
- In collaboration with Oxford University, Prof Thomas Lukasiewicz
- Linked to new collaboration on neurosymbolic reasoning with Samsung
- Topic of final year project by Jerome Brewster
Video anomaly detection

- Part of the SARAS project; research fellow Dinesh Jackson Samuel
- Problem: **identify any deviation from nominal behaviour in a video** (in particular the endoscopic video of a surgical procedure)
- Approach based on a **new SVD loss in an architecture inspired by GANomaly**
Funded through the new KTP with Supponor, but also part of SARAS.

The problem is to do accurate video scene understanding from a streaming video, in a temporally-consistent fashion.

We are exploring the boosting of features from the intermediate layers.

.. as well as the use of scene graphs to help the labelling..

.. and the notion of ‘soft’ segmentation to address boundary artifacts.

In the sports advertisement domain, we want to identify and the commercial signage around the pitch and inpaint them with virtual content.

Replaces Supponor’s current IR-based technology and active sensors.
Surgical Robotics
SARAS – Smart Autonomous Robotic Assistant Surgeon

- We are in charge of WorkPackage 6 – Situation awareness
  - Online surgeon action detection
  - Procedure stage segmentation
  - Anomaly detection
- We also contribute to WP5 (Perception)
  - Dynamic semantic understanding
  - Surgical tool tracking and pose estimation
- WorkPackage 3
  - Speech recognition module
- Wrapping up June 2021, possible further 6 month extension
The SARAS Surgical Action Dataset (ESAD)

- **Dataset of 4 real life, four hour-long videos** capturing lapascopic surgery procedures
- Annotation done with Microsoft VoTT
- **21 action classes**
- **Released for MIDL 2020 ESAD Challenge**
- [https://saras-esad.grand-challenge.org/Home/](https://saras-esad.grand-challenge.org/Home/)
- MIA journal in progress (Vivek)
Multi-domain surgeon action detection

- Builds on the MIDL 2020 challenge to launch a MICCAI 2021 challenge
- Makes use of the 4 real videos and 6 videos captured using artificial anatomies (phantoms) as part of SARAS
- Concept: exploring the opportunity of utilising cross-domain knowledge (in particular videos capturing procedures conducted on real as opposed to artificial organs and anatomies) to boost model performance on each individual task
- Compound performance measure assessing accuracy and parameter sharing
MAESTRO - Multi-sensing AI Environment for Surgical Task & Role Optimisation

- Goal: to devise an AI-assisted operating room of the 2050s
- Array of multiple sensors to monitor surgical checklists, teamwork
  - Monitoring of cognitive load linked to adverse events
  - MORL for improving team performance
- Led by George Mylonas at Imperial College, EPSRC bid @ full proposal stage

- Continual learning of perception and decision making models, both supervised and unsupervised
Machine learning
Statistical learning theory

• Problem: **model adaptation** in supervised learning

• **Statistical learning theory**: computes generalisation bounds for the test error of models

- Assumes training and testing distribution are the same!
- Proposal: **assume they come from a common convex set of probability distributions** (now part of Epistemic AI FET project)
Machine learning with random sets

- An example: max-entropy classifiers are a popular framework
- The entropy of the sought joint (or conditional) probability distribution of data and class is maximised
- Having picked a set of feature functions ..
- .. the constraint is that their empirical expectation equals that associated with the max entropy distribution
- This can be generalised by replacing probability distribution with random sets ...
- .. and constraining the empirical expectation to be bracketed by the lower and upper expectations
- This topic is also linked to the new Epistemic AI programme
Continual semi-supervised learning

• Interesting work has been recently directed at continual learning from streaming data in a fully supervised setting

• Focus mostly on avoiding catastrophic forgetting

• Continual learning in a semi-supervised setting remains a wide-open research question

• The problem can be reduced to a continual supervised learning setting under a 'multiple worlds' assumption

• the most likely labelling(s) of the current data stream is sought, then the model can be incrementally updated

• Workshop proposal to submit to IJCAI 2021

• Possible Horizon Europe collaborative project (see later)
Federated learning

• Concept: different parties can work together on better models without having to share the data

• Best suited to healthcare domain: hospitals working to achieve better diagnosis from x-ray images without disclosing patient data

• PhD student Devashish Bharti

• Ongoing collaboration with Converz, pending Innovate UK grant (https://www.converz.co.uk/)

• Possible approaches: meta-learning

• Devashish is working on a benchmark and performance measures for the problem
• Humans have complex mental lives, which make them unpredictable

• E.g.: children walking on the pavement spot an ice cream van on the other side – are they gonna cross?

• Solution: *giving machines theory of mind abilities, i.e. the ability to guess other agents’ reasoning process*

• [Leverhulme Grant with Cambridge Neuroscience, 2020-2024]

• Andrea Morelli (external), Bogdan Cirstea, Christelle Langley (Cambridge)
Neuro-symbolic AI

- **Integration of learning and reasoning** is one of the elements of a future artificial intelligence

- We have started collaborating on this topic with Samsung AI Cambridge (Efi Tsamoura)

- Various lines of research:
  - Loss functions expressing logical constraints on the output of a neural network
  - Modal logic constraints over sets of data points (linked to random sets)
  - Logical theories processing the output of a NN

- Appeal: **possibility of transferring knowledge across disparate domains**

- Devising **networks that generate propositional solutions** to problems (e.g. scene understanding)
Epistemic artificial intelligence

- Horizon 2020 FET (Future Emerging Technologies) project, coordinated by us
- 3M euros over 4 years, with KU Leuven and TU Delft
- Bottom line: uncertainty is not well modelled in AI, and that makes AI models brittle
- Change of paradigm: from striving for ‘generalisation’ or ‘adaptation’ to working with convex sets of models
- Use the available information to reduce the uncertainty about the ‘true’ model
- Well suited to the continual learning paradigm
- Contributions to supervised, unsupervised and reinforcement learning
Autonomous driving
AI for Autonomous Driving

- Can we predict future behaviour using machine theory of mind?
  - (1) future behaviour is guessed
  - (2) by explaining the chain of reasoning
- AI Research Fellow (to be hired) and PhD student Teeti
- Collaboration with Autonomous Driving group (Andy Bradley)
ROAD – The ROad event Awareness Dataset for Autonomous Driving

- We created the world's first ROad event Awareness Dataset for Autonomous Driving (ROAD)

- Annotating a number of videos from the existing Oxford RobotCar Dataset

- 22 videos, 122K frames, 560K bounding boxes, 1.7M labels

- Multi-label dataset: agent (11 classes), action (23), location (15)

- Aim: test prediction capabilities, complex road activities, situation awareness

- [IEEE PAMI, ICCV’21 workshop]
Formula Student - AI

• Collaboration with the Autonomous Tech student society and the Autonomous Driving group (Andy Bradley, Petar Georgiev)

• [https://www.imeche.org/events/formula-student/team-information/fs-ai](https://www.imeche.org/events/formula-student/team-information/fs-ai)

• FS-AI has been introduced to challenge student teams to develop an AI driver capable of controlling a purpose designed racing car

• Also ‘static’ event categories, e.g. students to also consider Real World Autonomous scenarios

• Our brand new Autonomous Formula Student team participated in the first edition of the UK Formula Student AI competition, coming 3rd place in 2019 and 1st overall in 2020!
Video synthesis for model adaptation

• Led by final year student Valentina Musat

• Inspired by Vid2vid framework (https://arxiv.org/pdf/1808.06601)

• GAN (Generative Adversarial Network) – based approach, need to enforce temporal consistency

• Goal is be able to synthesise realistic videos for training autonomous cars

• Leading to a weather augmentation paper to submit
Scale-invariant object detectors

- Robust object detectors with respect to scale
- Object-tube approach to detection
- Topic of final-year project by Aduen Benjumea Diepa
- Based on the SNIPER framework

- Instead of processing every pixel in an image pyramid, SNIPER processes context regions around ground-truth instances (referred to as chips) at the appropriate scale
- B. Singh, M. Najibi and L. S. Davis. SNIPER: Efficient Multi-Scale Training. NeurIPS 2018
- Possible application to autonomous driving and the Formula Student AI
- Possibility of a research agreement with Leonardo
AI for healthcare
Early dementia diagnosis

- Using gait analysis to provide an early diagnosis of dementia, for instance Parkinson’s
- In collaboration with Prof Helen Dawes (MORes), Dr Patrick Esser

Based on a metric learning approach we published on IEEE PAMI
- Work done by former PhD student Michael Sapienza
Multimodal monitoring of people in a coma

- Automated monitoring of people with prolonged disorder of consciousness

- Past EPSRC bid with Prof Helen Dawes and Prof Derick Wade (MOReS), in process of rewriting

- Core: modelling and detection of audio-visual events using multimodal deep learning
Rowing for Parkinson’s

- In collaboration with Prof Helen Dawes, Dr Shelly Coe (MOReS)
- Four people went on a row in the Indian Ocean for 70 days, one with Parkinson’s, three controls
- Deep learning for pose estimation
- Correlating body pose and motion with conditions
- Final year student Valentina Musat
Multi-condition diagnosis from gait analysis

- **MSc student Parijat Patel**

- **Purpose:** developing a classifier to *differentiate multiple neurological conditions based on gait analysis*, based on the 10 meter walk test

- Also classify the severity of the conditions individually after diagnosis

- Conditions considered: Parkinson’s, Stroke, Multiple Sclerosis, Huntington’s disease and Diabetes

- Data provided by the HLS School, MOReS (Patrick Esser, Helen Dawes)
Video diagnosis of Dupuytren disease

- Common form of arthritis of the hand
- Causes significant bending of a number of fingers
- Idea: pose estimation could be used to estimate the degree of severity
- Also: standard exercises can be performed before a phone camera; the video is then analysed to assess severity
- Past MSc dissertation by K. Parshotam
- In collaboration with Kennedy Institute (on hold) and University Medical Center Groningen
Empathetic AI

• Problem: communicating with people with cognitive impairment in care homes

• Idea: bespoke machine theory of mind approach

• Understanding both physical and emotional needs

• Machines willing to help?

• Linked to the Leverhulme grant

• Bid in preparation for EPSRC Healthcare Technologies call

• Partners: Derick Wade, Helen Dawes and Bogdan Cirstea
Uncertainty theory
Probability theory is not the only mathematical theory of uncertainty

Others exist: imprecise probabilities, random sets, belief functions are the most popular

Uncertainty measures can be represented as points of a convex space, and there analysed

I wrote two books on the topic, one coming out with Springer - Artificial Intelligence: Foundations, Theory, and Algorithms

Past work on the geometry of belief functions, fuzzy sets, combination rules, conditioning
The geometry of uncertainty – The geometry of imprecise probabilities

• My monograph on the geometry of uncertainty measures is finally out (after 9 years!)
• 860 pages!
• Most complete compendium of belief function theory
• Most complete overview of the general landscape of uncertainty theory
• Compendium of my geometric approach
• Agenda for the future of random set theory
Total belief theorem

• Goal: *generalise classical theorems of probability theory* to the belief function/random set case

• Example: *total probability theorem*

• UAI’17 paper on total belief theorem (with Dr Zhou Chunlai, China)

• Unlike the classical case, there are multiple solutions

• We proved an existence results, but a full study of the graph of all solutions is still missing
Generalised statistical inference and logistic regression

• How to infer a belief function/random set from sample data?

• This is the inference problem

• The two main existing mechanisms in belief theory rely on classical probabilistic inference

• Concept: generalise maximum likelihood inference in order to infer directly a belief function from data

• Further step: generalise logistic regression

• Can be applied to estimation of rare events
Our funding
Funding

• Current funding: ca £3,000,000

• Eight live funded projects for a total value of around £9M

• ECM Research Fellow, EU H2020 SARAS, EU FET Epistemic AI, Leverhulme Trust RPG, Innovate UK KTP with Createc, new KTP with Supponor, UKIERI exchange with IIT Bombay, Huawei Technologies research agreement

• Currently pending grant applications:
  • Olympia.ai (£5M): venture capital funding for a start-up on AI-powered coaching in sports
  • £300K EPSRC Transformative Healthcare Technologies: MAESTRO Jr (with Imperial)
  • £2M Innovate UK Smart Grant with Peoplespace (ZEBRA)
  • £500K Innovate UK Smart Grant with Converz
SARAS – Smart Autonomous Robotic Assistant Surgeon

- Funder: European Union (EU), Horizon 2020
- Budget: €4,315,640 (our share: €596,073)
- Personnel: 4 research fellows (Inna, Vivek, Jackson and Mohamed)
- Coordinator: Dr Riccardo Muradore, University of Verona, Italy
- Partners: Verona, Ferrara, Modena, Ospedale San Raffaele (Milan), Dundee, Medineering (Munich), ACMIT, Barcelona
Createc Knowledge Transfer Partnership

Funder: Innovate UK, Knowledge Transfer Partnerships
Amount: £190,000
Duration: May 2019 – May 2021
Personnel: Neha Bhargava
Partner companies: Createc Technologies, Sportlight.ai

https://www.sportlight.ai/
Theory of mind at the interface of neuroscience & AI

The Leverhulme Trust

- Funder: Leverhulme Trust, Research Project Grant RPG-2019-243
- Amount: > £273,000
- Personnel: two postdoctoral research assistants (Bogdan and Christelle)
- Duration: Feb 2020 – Feb/Mar 2024
- Co-investigator: Professor Barbara Sahakian, University of Cambridge
ECM Fellow in AI for Autonomous Driving

- **Funder:** School of Engineering, Computing and Mathematics
- **Amount:** £100,000
- **Personnel:** one research fellow
- **16 months left on the project**
- **Co-investigator:** Dr Andrew Bradley, Autonomous Driving group
- **Testing of machine ToMs in a simulated environment (CARLA)**
Some novel paradigms for analyzing human actions in complex videos

- Funder: UKIERI
- Amount: £48,076
- Personnel: Omkar Gune, Dipesh Tamboli
- Duration: Apr 2019 – Aug 2021
- Topic: continual zero-shot action recognition
- Creating benchmark from standard UCF-101 dataset
- Co-investigators: Prof Biplab Banerjee, Prof Subhasis Chaudhuri
Modelling of complex activities

- Funder: Huawei Technologies
- Amount: £278,000
- Personnel: Salman Khan and Ajmal Shahbaz
- Duration: Dec 2019 – Nov 2021
- Topic: modelling and detection of complex activities in real time
  - Salman augmented ROAD with complex road activities
  - Implemented ROI pooling pipeline
  - Working on sparsity constraints
Epistemic AI

- Funder: EU Horizon 2020
- Amount: 1,209,000 euros (3M in total)
- We are the Coordinators
- Personnel: two research fellows + two PhD students + one lab administrator
- Duration: Mar 2021 – Feb 2025
- Topic: injecting second-order uncertainty into the foundations of artificial intelligence
KTP with Supponor

- Funder: Innovate UK
- Amount: £310,000
- Personnel: one KTP associate
- Duration: 3 years
- Topic: video scene understanding applied to professional sports footage
  - Consistent segmentation, video inpainting
  - Handling of occlusions, boundaries
Our team
Personnel

- Faculty members: Prof Fabio Cuzzolin (Director), Dr Tjeerd Olde-Scheper (Senior Lecturer), Dr Andrew Bradley (Senior Lecturer), Dr Alex Rast (Lecturer), Dr Matthias Rolf (Senior Lecturer)

- New staff member Alex Rast

- Current personnel: 6 Research Fellows (Vivek, Inna, Dinesh, Mohamed, Bogdan, Christelle), 1 KTP Associate (Neha), 3 PhD students (Salman, Devashish and Wojtek, based in Cambridge), 3 MSc students, 3 final year students, 7 remote collaborators (Filippo, Andrea, Gurkirt, Suman, Reza, Silvio, Vincenzo)

- Appointed: one research fellow (Ajmal Shahbaz), one PhD student (Izzedin Teeti)

- Upcoming: one ECM postdoc, two E-pi fellows, two E-pi PhD students, one KTP associate, one lab administrator

- In total we are expected to be around 35 people in 2021

- Some people will leave us 😞
Our partners
Institute for Ethical AI

- Created by Prof Nigel Crook
- [https://robotics.ecm.brookes.ac.uk/?p=574](https://robotics.ecm.brookes.ac.uk/?p=574)
- Co-director Kevin Maynard
- Fabio is in the advisory group of it
- Aims at establishing and maintaining a cross-university network on the topic
- Themes: explainability, ethical implications of AI, ethical AI from a technical point of view, advising
- A network of interested companies has been set up
Healthy Ageing network

- Scheme funded by UKRI (the UK research council)
- Coordinated by Juliet Bligh of RBDO
- **Cross-university network involving Business, Health Sciences, Architecture, and us**
- Topics: sustaining physical activity, living well with cognitive impairment, design for age-friendly homes, etcetera
- **Trailblazer programme (£40M), Autumn 2019**
- Goal: stimulate new ideas from a wide range of businesses and social enterprises to develop and deliver products, services and business models at a large scale to support people as they age
OxCATTS

• Oxford Clinical Allied Technology and Trial Services Unit
• [https://oxcatts.com/](https://oxcatts.com/)
• Funded by Helen Dawes
• Fabio is in the Steering Committee for it
• Aim: increase cross-fertilisation between our work in AI and in healthcare/rehabilitation
• Mission is to provide consultancy and support research grant applications
Within the School and University

Cognitive Robotics (Prof Crook and Dr Rolf)

MOReS (Prof Dawes, Wade; Dr Esser)

Autonomous Driving group (Andrew Bradley)
Within the UK

Torr Vision Group, Oxford University (Prof Torr)

Computer Science Dept, Oxford University (Prof Lukasiewicz)

Neuroscience, Cambridge University (Prof Sahakian)

Imperial College London (Dr Mylonas)
Across the world

Altair Robotics Lab, Verona (Prof Fiorini, Dr Muradore)

Federico II University, Naples (Prof Di Gironimo)

Indian Institute of Technology, Bombay (Prof Banerjee and Chaudhuri)

KU Leuven, Belgium (Dr Shariatmadar)

TU Delft, Netherlands (Prof Yorke-Smith)
Companies

Huawei Technologies (Dr Zhan Xu)

Cisco Systems (Dr William Wu)

Createc (Matt Mellor, Ian Cowling)

Supponor (Andrew Crean, Steve Plunkett)
Companies

- Al Labs, Bologna (Massimo Ciociola)
- Samsung AI (Efi Tsamoura)
- Peoplespace (Halbyn Rich)
- Ocado (Dr Graham Deacon)
Societies and networks

- ContinualAI (Vincenzo Lomonaco): https://www.continualai.org/

- CLAIRE: European federation of AI laboratories (https://claire-ai.org/)

- The Society for Imprecise Probability (http://www.sipta.org/)

- The Belief Functions and Applications Society (https://bfasociety.org/)
The next steps
Upcoming grant applications

- A number of grant applications are in the making

  - €10M Horizon Europe - MAESTRO - Multi-sensing AI Environment for Surgical Task & Role Optimisation (led by Imperial)
  - €4-5M SARAS++ - follow up of SARAS
  - Horizon Europe FET Open on Continual Learning (with ContinualAI and others)?
  - £1.5M EPSRC bid on Epistemic AI for Autonomous Driving (CoI Andrew Bradley)
  - £1.5M EPSRC Healthcare Technologies on Theory of mind for the cognitively impaired (CoIs Dawes and Wade)
  - £250K Leverhulme RPG on autonomous driving (led by Bradley)
  - Other high-impact areas to seek funding for: self-supervised learning, goal-changing machines, epistemic modelling of pandemics
Project Olympia

• **The world’s first AI coaching app**

• Powered by our action detection technologies

• **Negotiating initial venture capital for £5,000,000, 10+ researchers and engineers**

• Co-founders: Pascal Pert, EIT, Chairman of innovation and marketing at World Taekwondo Europe

• Mehdi M., former President of British Student Taekwondo Federation
Project Olympia

- Stage 1: compilation of simple stats on no of kicks, jumps, etc
- Stage 2: assisted video review of significant events
- Stage 3: video-based assessment of quality of exercise
- Will be based in the Wood Centre for Innovation, Oxford (?)
- Numerous gold medallists and testimonials and influencers
£2M Innovate UK Smart Grant with Peoplespace

Aim is to create safe, infection-reduced workplaces

System to capture and analyse data from an array of sensors

Core AI suite for the multimodal detection of human activities in real time and localisation on floorplan

Risk assessment of various areas

Automated track and trace

Informing how to reduce disease transmission rates
• Follow-up from the SARAS project on surgical robotics

• Big industrial partners like Philips, Medtronic (the largest supplier of medical electronics), Karl Storz (the leading endoscope manufacturer)

• Budget: TBD, but in excess of 5M

• Looking for appropriate Horizon Europe call

• Probably also led by Verona
MAESTRO

- Innovation Action to deliver the smart operating room of the future
- Big industrial partners including Johnson & Johnson; Again looking for new Horizon Europe calls
- Coordinated by Imperial College (Mylonas); Budget: ca 10M euros
Continual semi-supervised learning

- Potentially a FET bid under the new Horizon Europe framework
- Suitable deadline in May 2021
- In partnership with Continual AI (Vincenzo Lomonaco)
- We are proposing an IJCAI 21 workshop on this topic
- Focus on learning from unlabelled data streams (continual semi-supervised learning)
- Incremental updating of model (classifier or regressor) based on suitable constraints
Epistemic AI

• What are the main targets of the Epistemic AI programme?
  • **Theory of constrained optimisation under epistemic uncertainty**
  • **Losses for random sets that generalise cross entropy** in deep learning
  • GANs (generative adversarial networks) rely on stochastic sampling from a latent variable
    • Design **robust GAN framework based on random set theory**
  • Reinforcement learning also relies on the framework of (Partially Observable) Markov Decision Models
    • **Generalisations of MDPs and Markov chains exist**
  • Can we lay down the foundations of a ‘**robust’ reinforcement learning framework’?*
  • Generalising Belmann’s equations
• **Self-supervised learning** empowers us to exploit the variety of labels that usual come with the data for free – leading to ‘human-level’ intelligence??

• Technically, the idea is to define an auxiliary task for which we already have labels, 'hidden' within the structure of the data itself

• This happens by defining a self-supervised task, also known as **pretext task**, which guides us to a supervised loss function

• However, no theoretical foundations for self-supervised learning yet exist

• Our goal is to provide a [theoretical justification for self-supervised learning through a combination of functional analysis and optimisation theory](#)
Goal-changing machines

- That’s fine, but what about the ability of people to change their goal(s) in time, or juggle various different goals at the same time?
- Seeking models that update their very objective function with time
- Interesting discussion with Prof Gary Browning
- Again, strong intuition and insights can come from psychology and neuroscience
- https://chrisguillebeau.com/how-goals-change-over-time/
Our targets
Medium-term objectives

- **Increasing output in terms of publications** -> ideally we should be in a position to submit 10 papers a year to major computer vision and AI conferences

- **Boosting our citations figures** -> investing in frontier topics with high potential impact
  - Target top venues such as Nature (as we did for our ToM editorial)

- **Further doubling the research funding** to reach £5-6M
  - Research fellows should start engaging with grant applications

- **Attracting venture capital and generating spin-offs**, starting from the Olympia project -> another option is applying our ToM concept to autonomous driving

- **Organising workshops and challenges, releasing new benchmark datasets** (e.g. ROAD, ESAD and the continual learning ones)

- In the medium term, the **creation of an Oxford Institute for Next-generation AI**