

Miguel Xochicale – Introduction

RSGD slides

November 30, 2022

Miguel Xochicale, PhD ([@_mxochicale](https://twitter.com/_mxochicale) @mxochicale)

Advanced Research Computing Centre and WEISS
University College London



This slide is licensed under a Creative Commons “Attribution 4.0 International” license.
Get source of this slide and see further references from

Table of Contents

1. My trajectory
2. PhD in Human-Robot Interaction (2014-2019)
3. Ultrasound Needle Tracking (2019-2021) @ KCL
4. AI-enabled echocardiography (2021-2022) @ KCL
5. Ultrasound Image Synthesis (2022 – Present)
 - 5.1. Clinical background
 - 5.2. Research aims
 - 5.3. Phantoms for AI-based fetal biomechanics
 - 5.4. Building AI for Medical Devices
6. Appendix
 - 6.1. I: Fetal Poses, II: Fetal Behaviours
 - 6.2. Growing Baby: 3D Print-ready Models
 - 6.3. State-of-the-art on modelling fetus

My trajectory



Miguel
Xochicale



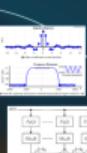
H.S.



2000



B.Sc.



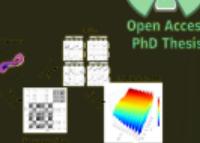
M.Sc.



T.A.

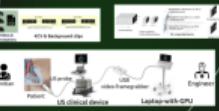
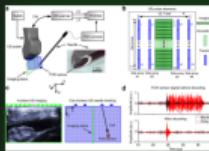
Ph.D. in Human-Robot Interaction
University of Birmingham

Nonlinear
Analysis
Data mining
Machine learning
Deep learning
Big data



Ph.D.

Research Associate in
Ultrasound Guidance Interventions
AI-enable echocardiography
King's College London



R.A.
R.E.

Research Engineer
University College London



Goal: to expand applications to thoracic
Goal: to increase free world for interventional
Goal: to disseminate all research

2010

2020 29-Nov-2022

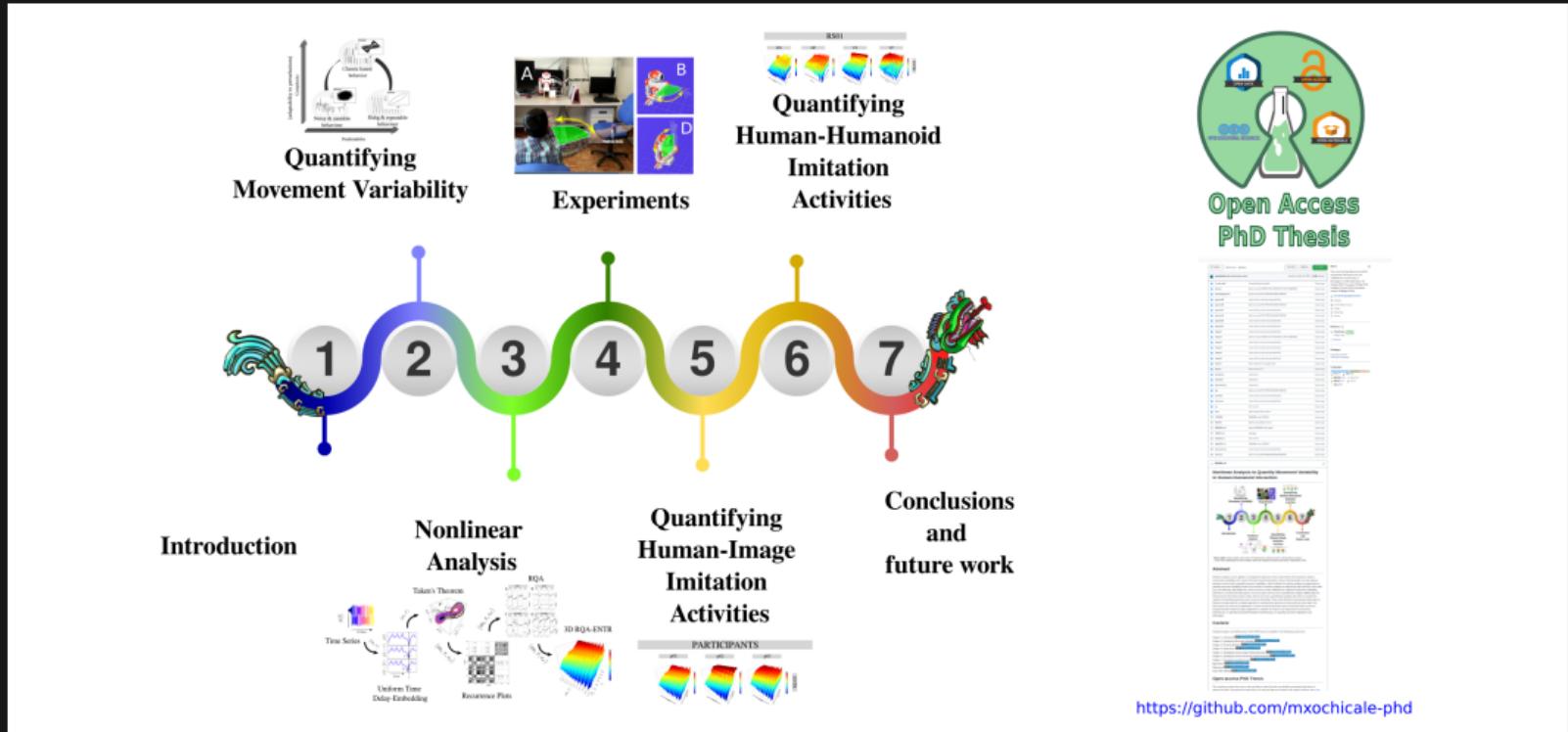
2030 time [years]

Table of Contents

1. My trajectory
2. PhD in Human-Robot Interaction (2014-2019)
3. Ultrasound Needle Tracking (2019-2021) @ KCL
4. AI-enabled echocardiography (2021-2022) @ KCL
5. Ultrasound Image Synthesis (2022 – Present)
 - 5.1. Clinical background
 - 5.2. Research aims
 - 5.3. Phantoms for AI-based fetal biomechanics
 - 5.4. Building AI for Medical Devices
6. Appendix
 - 6.1. I: Fetal Poses, II: Fetal Behaviours
 - 6.2. Growing Baby: 3D Print-ready Models
 - 6.3. State-of-the-art on modelling fetus

PhD in Human-Robot Interaction (2014-2019)

University of Birmingham

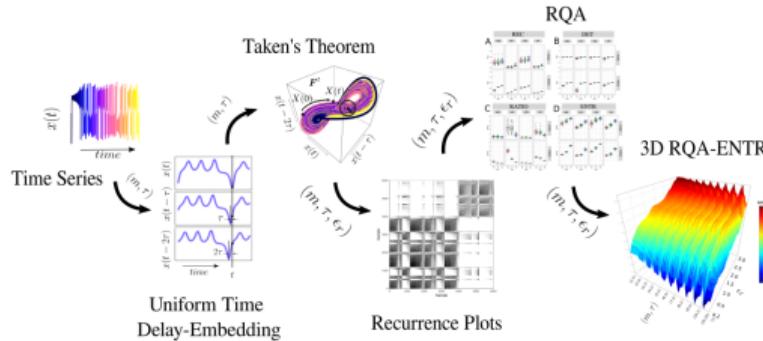


<https://github.com/mxochicale-phd>

PhD in Human-Robot Interaction (2014-2019)

University of Birmingham

Nonlinear Time-Series Analysis → Applications

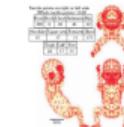


Quantification of skill learning



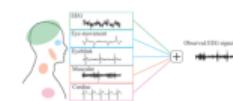
- * Surgical Skills Assessment
- * Robot-Assisted Surgery

Fetal behavioral development



- * General movements
- * Arm/Legs Movers
- * Hand/Face Contacts

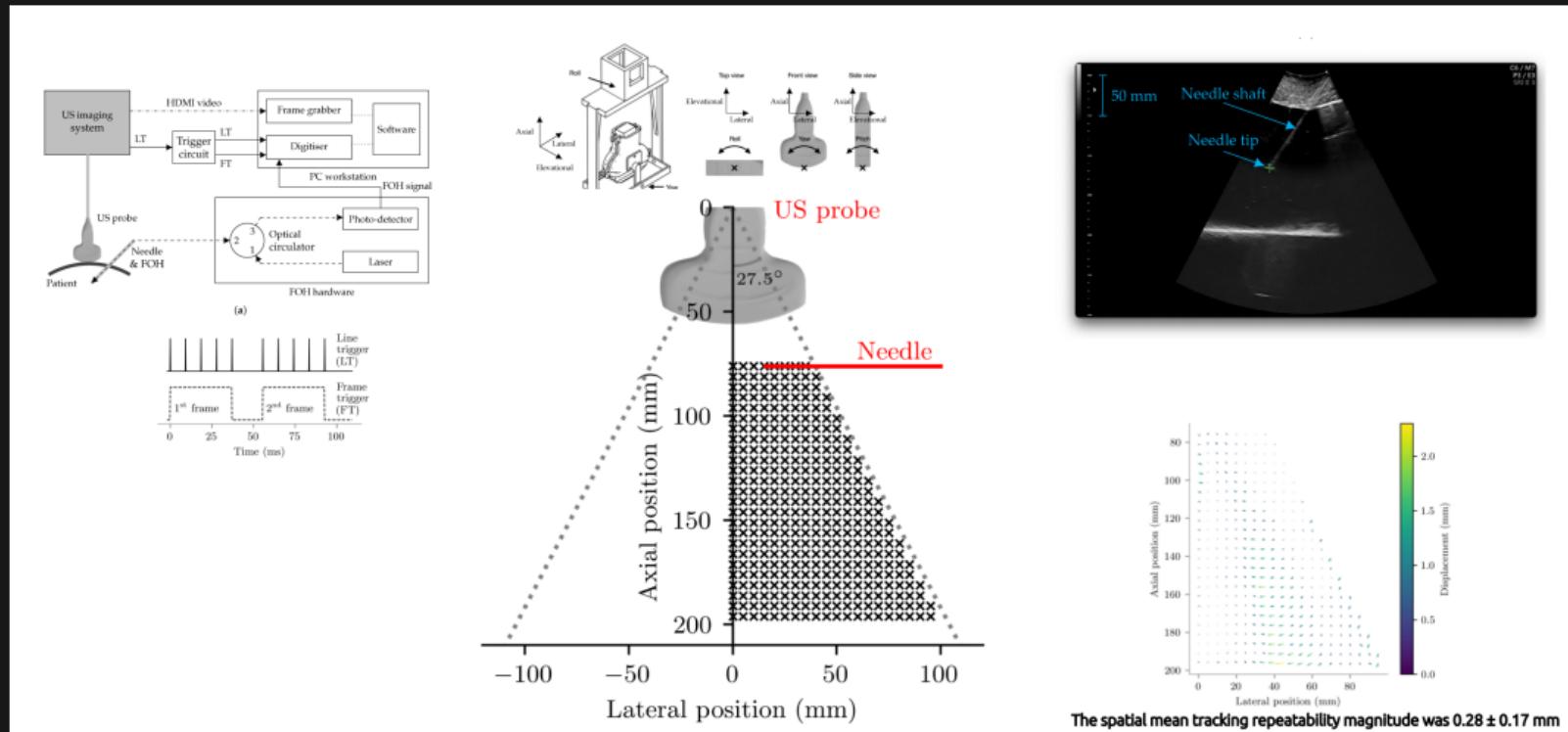
Nonlinear Biomedical Signal Processing



- * EEG time series
- * Heart rate variability
- * Eye Movements

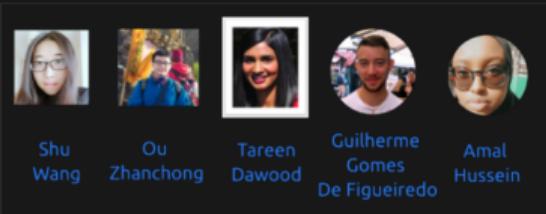
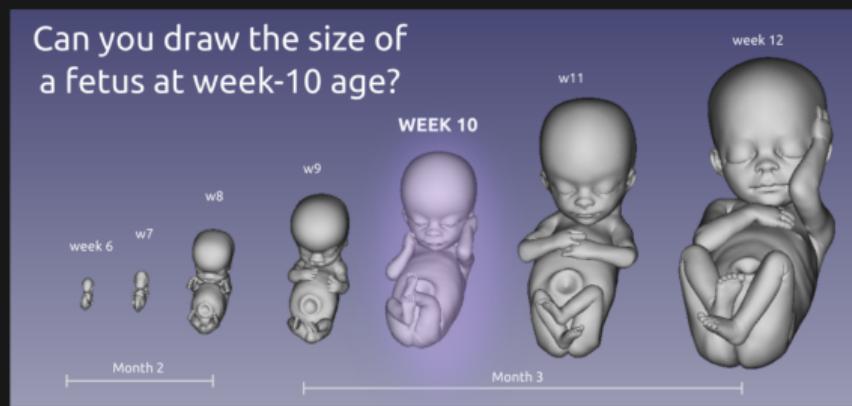


Intraoperative Needle Tip Tracking (2019-2021) @ KCL



Finding a fETus with UltraSound (FETUS) (2019-2021) @ KCL

[🐾ACTIVITY]: Guessing Fetal Growth



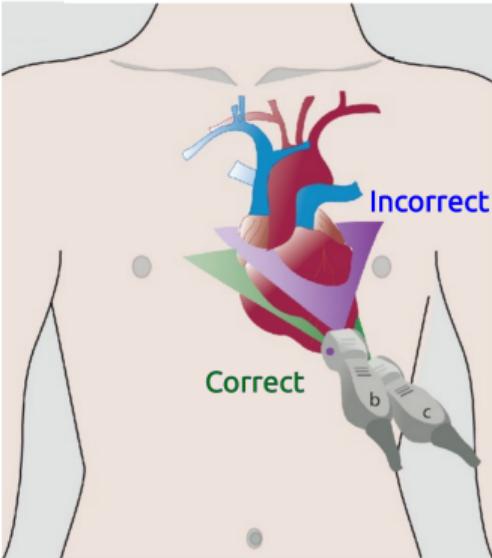
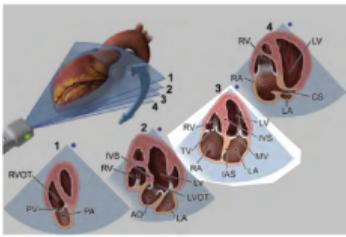
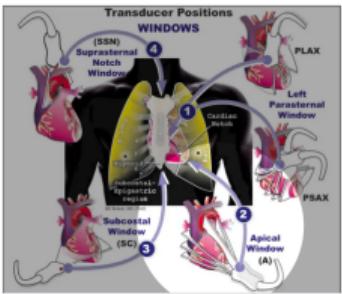
Souvenirs



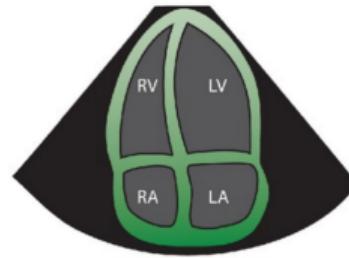
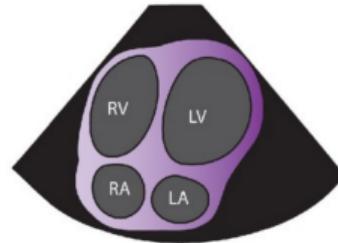
[🐾ACTIVITY]: Interactive Ultrasound Imaging



The four-chamber view



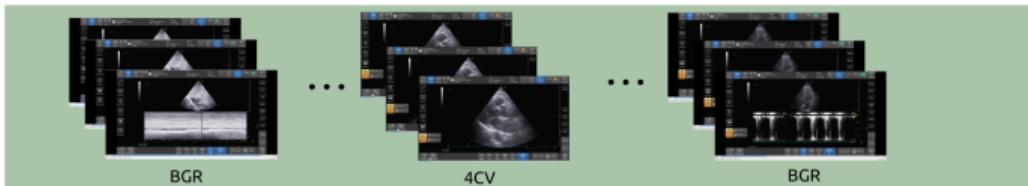
Foreshortening of heart



Ideal image for apical view
without foreshortening

Processing videos for echocardiography

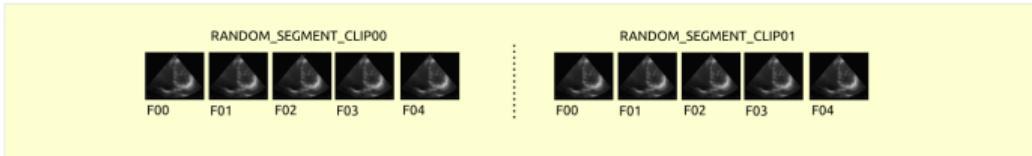
Video on disk



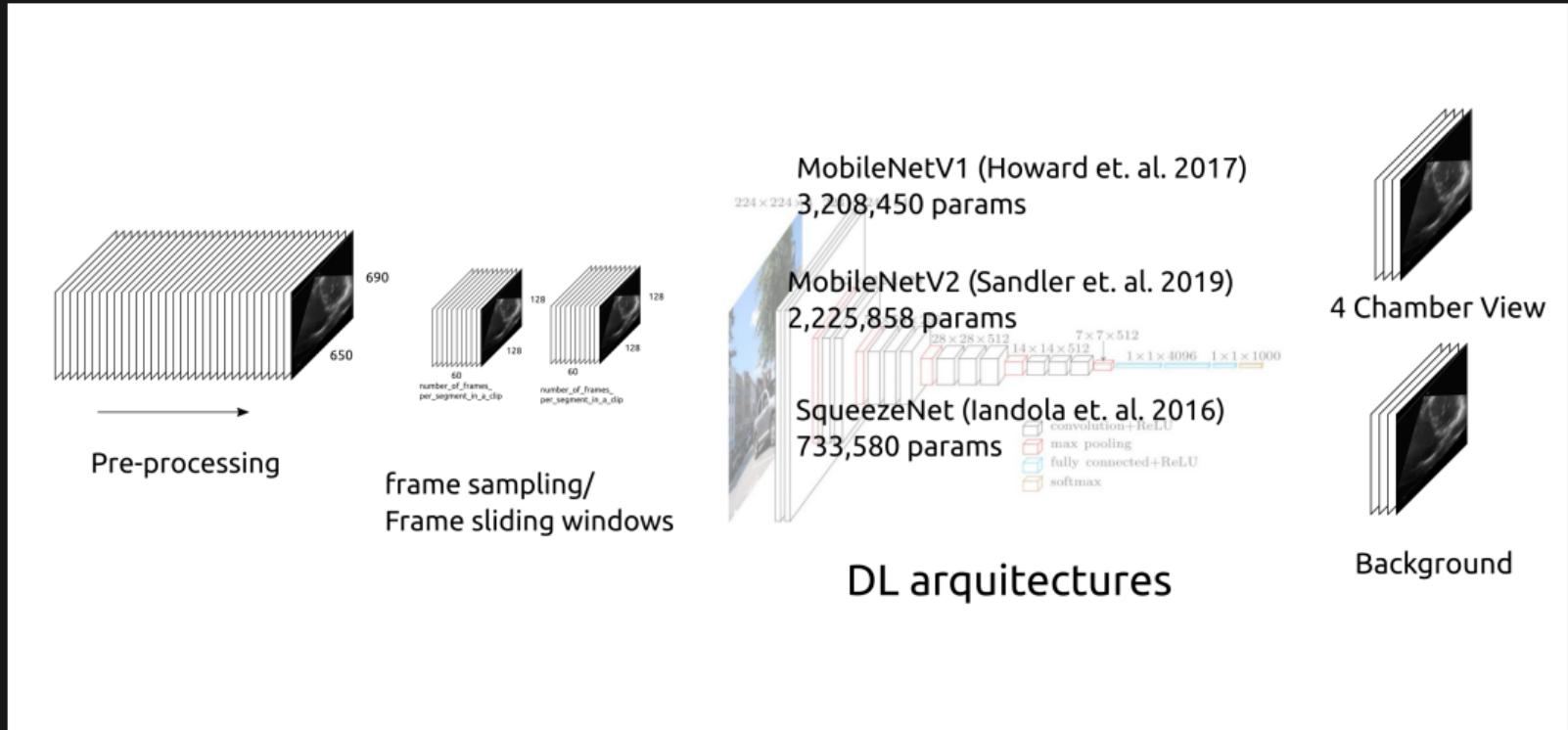
4CV clips



Segment sampling



Classification of US images with thinner neural networks



Low-cost clinical system

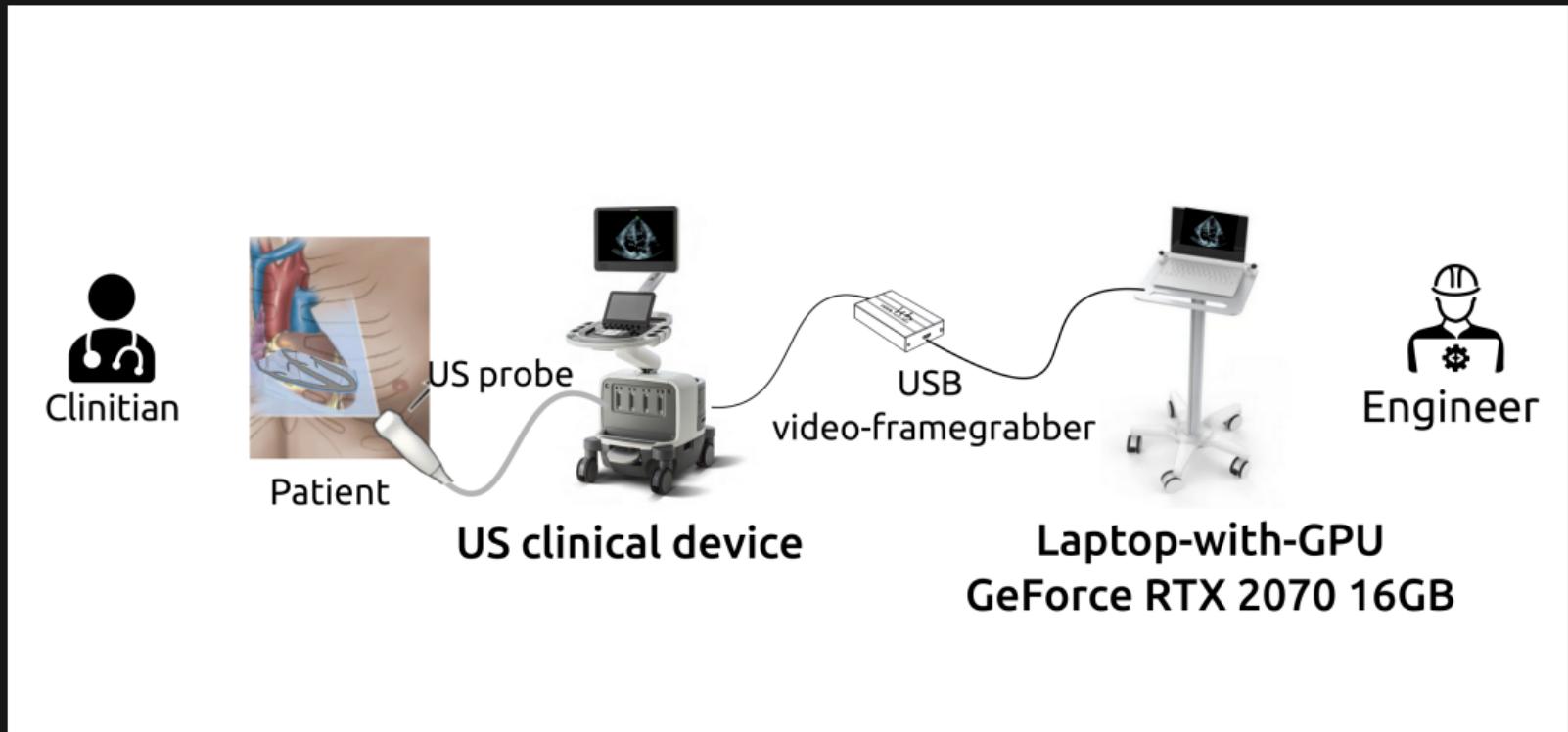
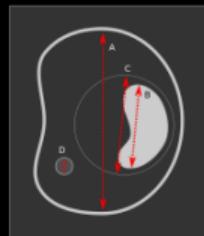
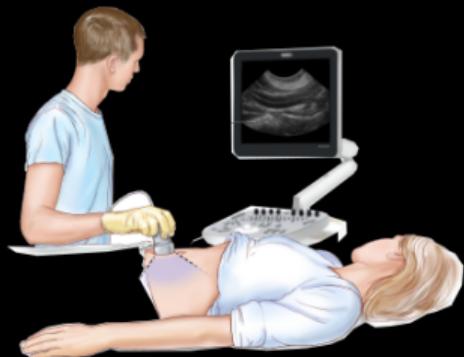


Table of Contents

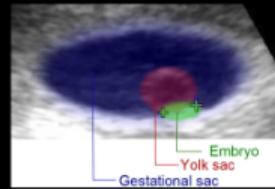
1. My trajectory
2. PhD in Human-Robot Interaction (2014-2019)
3. Ultrasound Needle Tracking (2019-2021) @ KCL
4. AI-enabled echocardiography (2021-2022) @ KCL
5. Ultrasound Image Synthesis (2022 – Present)
 - 5.1. Clinical background
 - 5.2. Research aims
 - 5.3. Phantoms for AI-based fetal biomechanics
 - 5.4. Building AI for Medical Devices
6. Appendix
 - 6.1. I: Fetal Poses, II: Fetal Behaviours
 - 6.2. Growing Baby: 3D Print-ready Models
 - 6.3. State-of-the-art on modelling fetus

Dating US scan (12-week scan)



A: Gestational sac (GS),
B: Crown-rump length (CRL),
C: Amniotic sac (AS),
D: Yolk sac (YS)

GS, AS, YS



Crown-rump length
(CRL)



Nuchal translucency
(NT)



Challenges of ultrasound biometric measurements

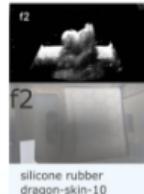
- ▶ Operator dependant
- ▶ Position of the baby
- ▶ Similar morphological and echogenic characteristics in the US
- ▶ Few public datasets are available (we have only found two)

Research aims

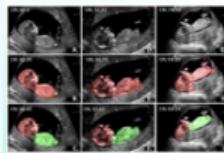
- ▶ Investigate and implement deep-learning methods for synthetic fetal ultrasound imaging of normal and abnormal cases;
- ▶ Propose and apply methods to evaluate quantitative and qualitative images to investigate fetal biomechanics; and
- ▶ Design and test fetal phantoms that mimic various poses, and fetal ages.

GAN-based fetal US imaging

**1. Small datasets
of 100 images
(10-14 weeks
gestation)**

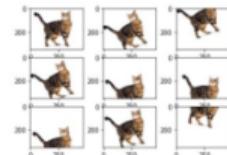


Phantoms
(age,
US-devices,
pose)

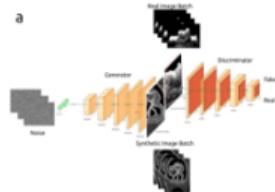


Real fetal
US images

**2. Image processing
(anonymization,
cropping, augmentation,
etc)**



3. GANs
(loss functions,
autoencoders,
hyperparameter search,
etc)



GAN architectures

- MNIST-GAN (+basic net)
- Fast-GAN (+small datatsets of 100 images)

**4. Quality assessment
of Synthetic US
images**



- Visual Turing test
- CNR
- Texture Analysis

GAN-based fetal imaging

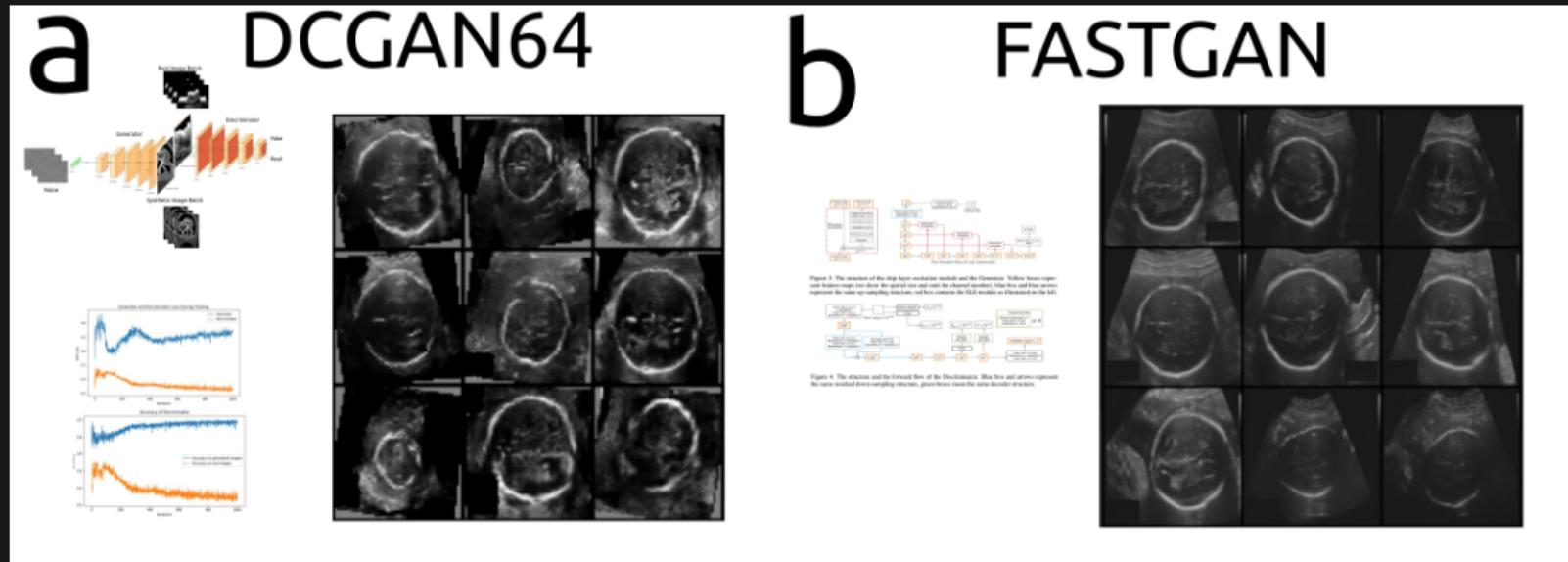


Figure: (a) DCGAN arquitecture, loss functions for DC-GANs and batches of synthetic fetal head images, (b) FASTGAN arquitecture and batches of synthethic fetal head images

[(a) Bautista et al. 2022, "Empirical Study of Quality Image Assessment for Synthesis of Fetal Head Ultrasound Imaging with DCGANs" MIUA <https://github.com/budai4medtech/miua2022> (b) Liu et al. 2021 "Towards Faster and Stabilized GAN Training for High-fidelity Few-shot Image Synthesis" <https://arxiv.org/abs/2101.04775>]

Difussion models for fetal imaging

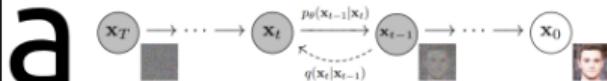


Figure 2: The directed graphical model considered in this work.



Figure 1: Generated samples on CelebA-HQ 256×256 (left) and unconditional CIFAR-10 (right).



Figure 8: Interpolations of CelebA-HQ 256×256 images with 500 timesteps of diffusion.

b

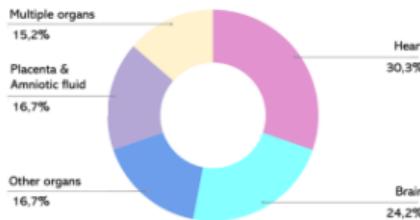
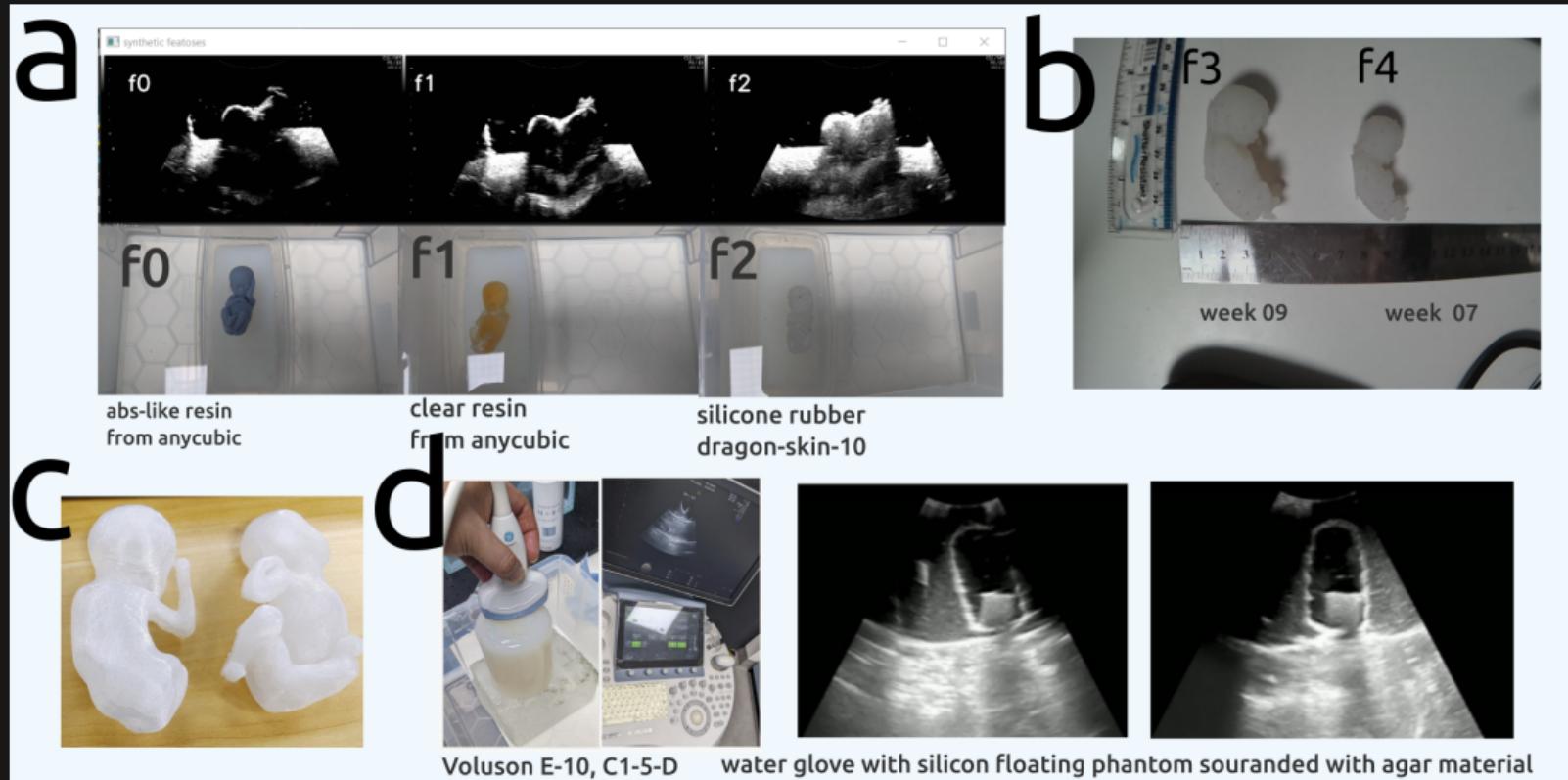


Fig. 7. Number of papers surveyed in Sec. IV according to the anatomical structure.



Fig. 3. Visual samples of the most common fetal standard planes.

Phantoms for AI-based fetal biomechanics



Building AI for Medical Devices

~20FPS

Jetson Nano



Jetson Assisted Intelligent Qualification & Navigation for Real-time US Stream

Cupid®
> 20 FPS

Professor Dong Ni at Shenzhen Uni
Medical UltraSound Image Computing (MUSIC)

GE Voluson e10



~60FPS

Clara AGX



Clara Holoscan EGX



- * 4K/UltraHD/2K/HD/SD up to 50/60p
- * HDMI 2.0 (port 1 & 2)
and HDMI 1.4b (ports 3 & 4)
- * Linux Ubuntu support
for 20.04 LTS, 18.04 LTS, 16.04 LTS.

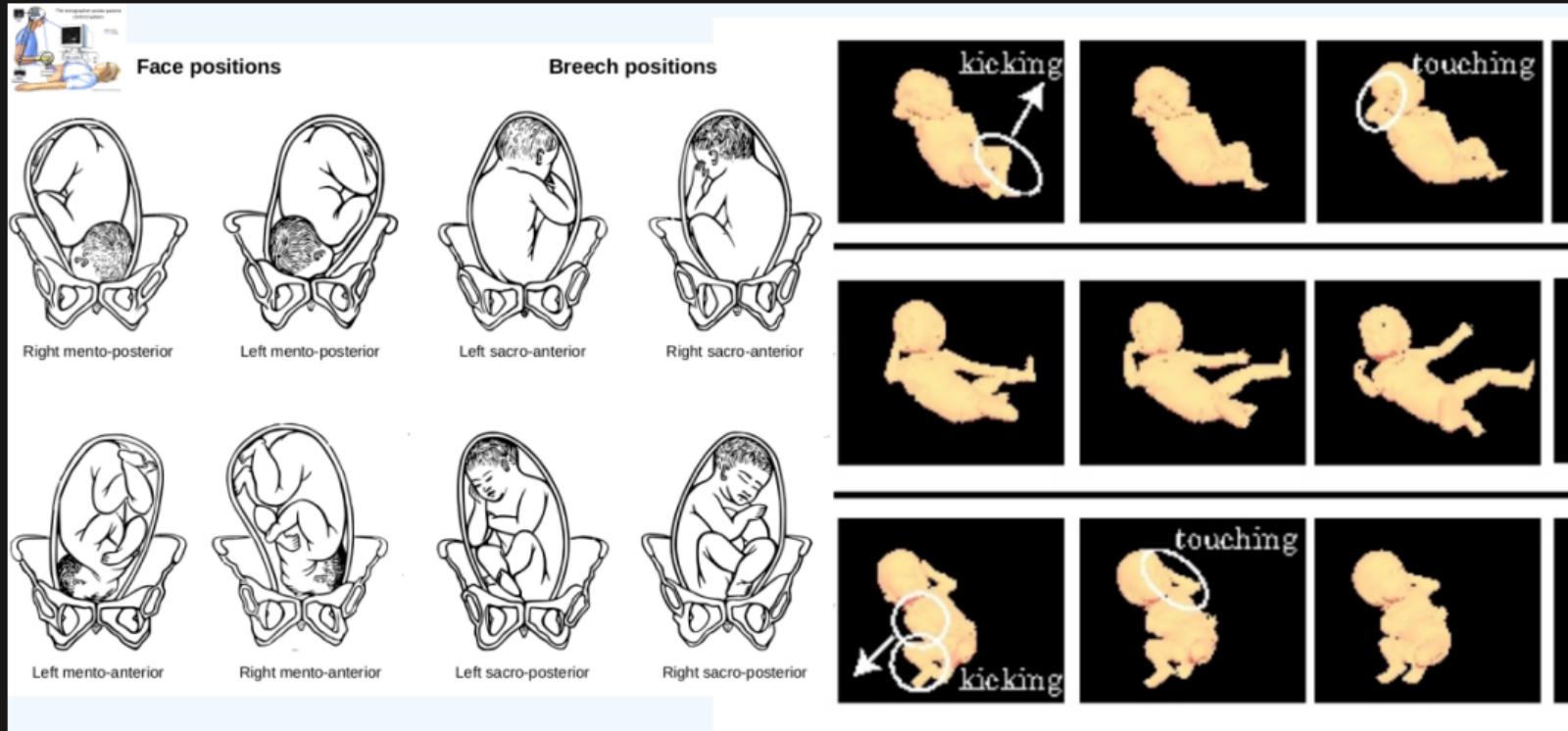
* preferred device for clinicians
to perform fetal development

* Ten years of hardware and software
support to ensure product longevity

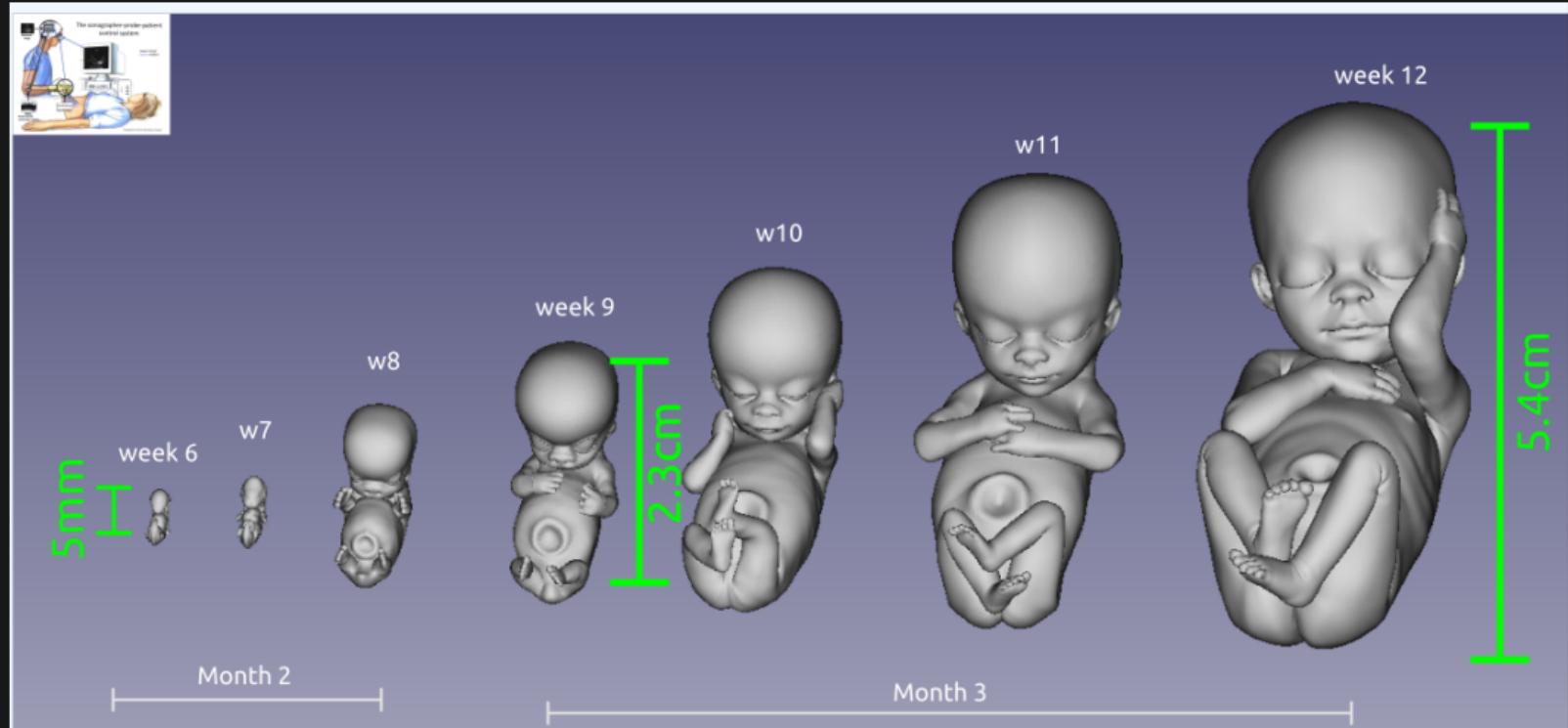
Table of Contents

1. My trajectory
2. PhD in Human-Robot Interaction (2014-2019)
3. Ultrasound Needle Tracking (2019-2021) @ KCL
4. AI-enabled echocardiography (2021-2022) @ KCL
5. Ultrasound Image Synthesis (2022 – Present)
 - 5.1. Clinical background
 - 5.2. Research aims
 - 5.3. Phantoms for AI-based fetal biomechanics
 - 5.4. Building AI for Medical Devices
6. Appendix
 - 6.1. I: Fetal Poses, II: Fetal Behaviours
 - 6.2. Growing Baby: 3D Print-ready Models
 - 6.3. State-of-the-art on modelling fetus

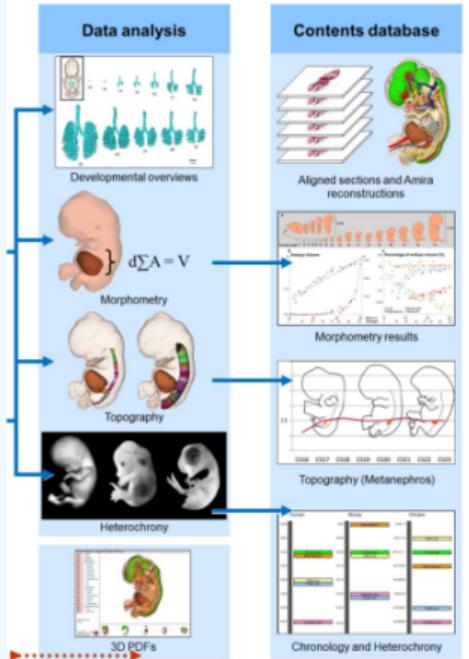
I: Fetal Poses, II: Fetal Behaviours



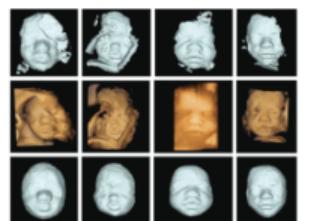
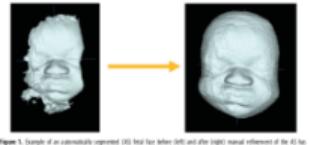
III: Fetal Growth



State-of-the-art on modelling fetus



Bakker2016-in-science



clark2020-in-RS



morth2019-in-Eurographics.png

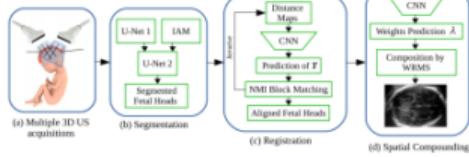


Fig. 1. Overall diagram of the proposed methodology for fetal head composition.

perez-gonzalez2020-in-ASMUS-PIPPi.png

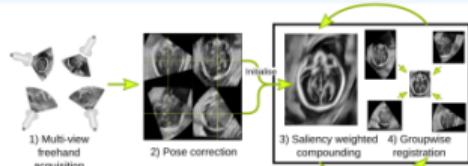


Fig. 1. Processing pipeline for complete fetal head compounding.

wright2019-in-MICCAI



Figure 3: Orthogonal slices through examples of compounded surfaces (a). Elliptical twisting trajectory (b) and TSMF freehand reconstruction (c) for a sequence from whole body fetus phantom. The sequence of images of the static phantom were taken with a very wide range of probe directions as seen in the top-right image. The images from the sequence are then registered and finally compounded to produce the images shown here.

khanal2018.png