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The VIVO Hub for Enhanced Independent Living – Tackling Hard Problems with Soft Robotics, Machine Learning, and Timely Edge Inference.



IMPERIAL

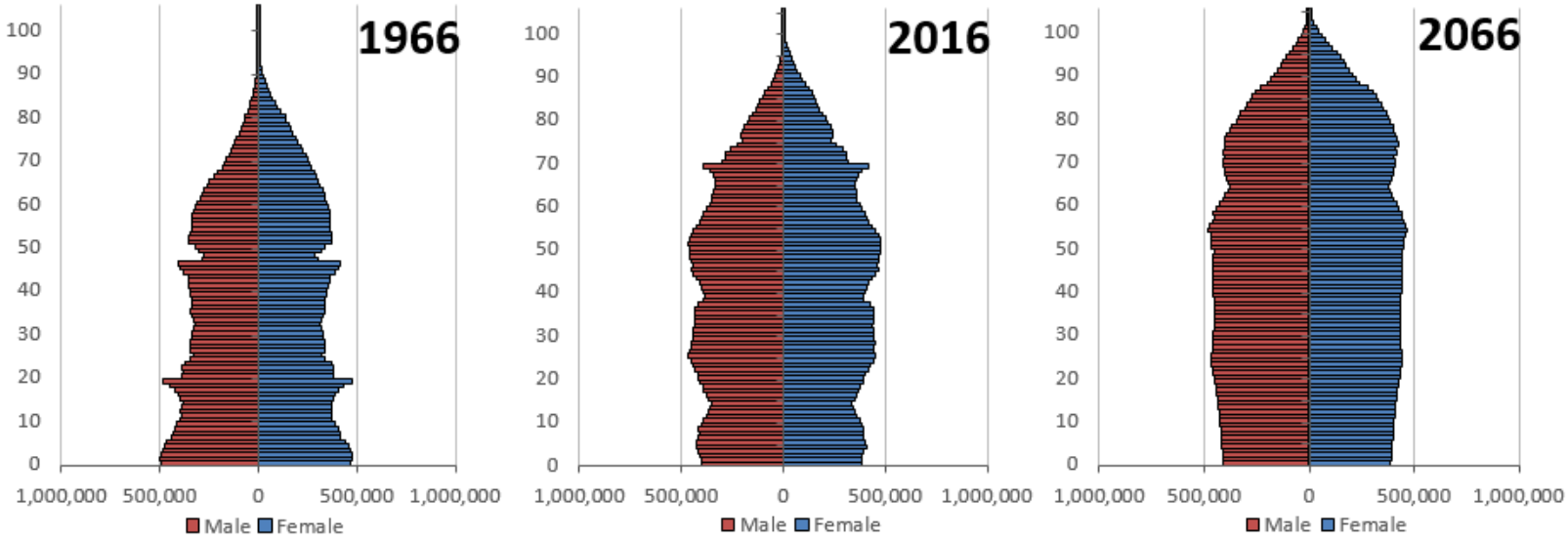
University of BRISTOL

UCL

University of Strathclyde Glasgow

UWE Bristol University of the West of England

Population demographics UK



627,000 extra care staff needed by 2030

The Health Foundation REAL Centre

1

Collaboration of UK universities



The Hub brings together experts from the University of Bristol, UWE, UCL, Imperial College London, the University of Strathclyde and QMUL, funded by EPSRC

2

Restoring confidence and independence



Ageing or disability shouldn't mean giving up the things you love, like getting up from a chair or going out with family. The Hub's aim is to help people feel confident and active again.

3

Smart wearable tech for everyday life



The technologies include soft robotic suits, smart garments and wearable systems that support standing, walking further, preventing falls, and even help with tasks like climbing stairs or standing up.

4

Integrated sensors for real-time help



Sensors in the home and on the body work together to monitor health, anticipate needs, and help wearable assistive tech respond when needed., smoothly and more naturally

5

Designed with real people in mind



From co-design with users to real-world testing (from lab to home), people's experiences help shape how the technology works, so it's comfortable, discreet and truly useful.

6

Built to be used, not just studied



VIVO Hub technologies are developed with industry and healthcare partners, so they can move beyond the lab and into the NHS, care settings and everyday homes.

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VIVO Hub Overview:

- £15 million EPSRC funded grant taking place from December 2024 to December 2030
- The main project goals are:
  1. *Fall prevention*
  2. *Independent dressing*
  3. *Mobility in the home*
  4. *Supporting activity out of the home*

The Right Trousers of the Future



Easy Dressing Waistband
Automatically loosens or tightens for easy dressing and undressing.

Power and Electronics
Small and light, using the latest technology. You control how much assistance the clothing gives.

Active-Stiffening Brace
Provides support at the knee to help you stand up for longer.

Artificial Muscles
Powerful artificial muscles that help you stand up and move around.

IMU Sensors
Inertial Measurement Units sense your posture, allowing the clothing to help you move and prevent falls.

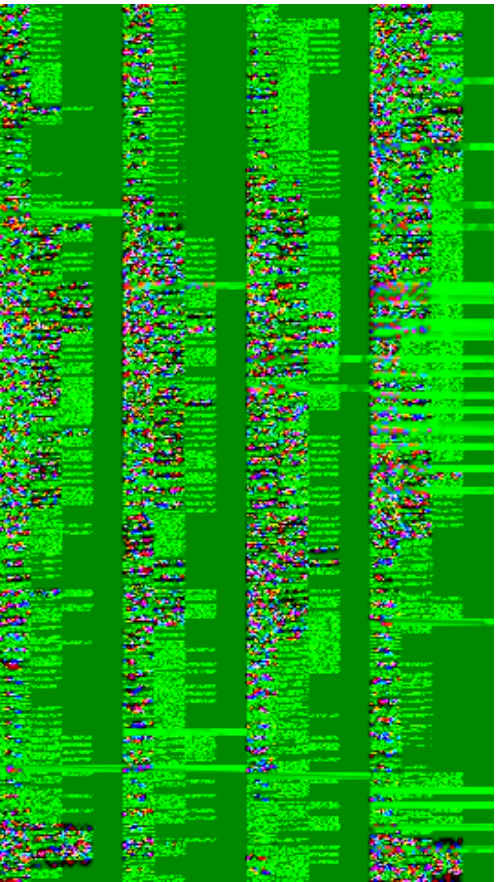
FES Arrays
Functional Electrical Stimulation arrays can stimulate your muscles to help with rehabilitation and let you move with your own strength

Foot Straps
Foot straps keep the clothing in place and make sure it provides assistance comfortably.



BBC sky REUTERS CLICK CBS

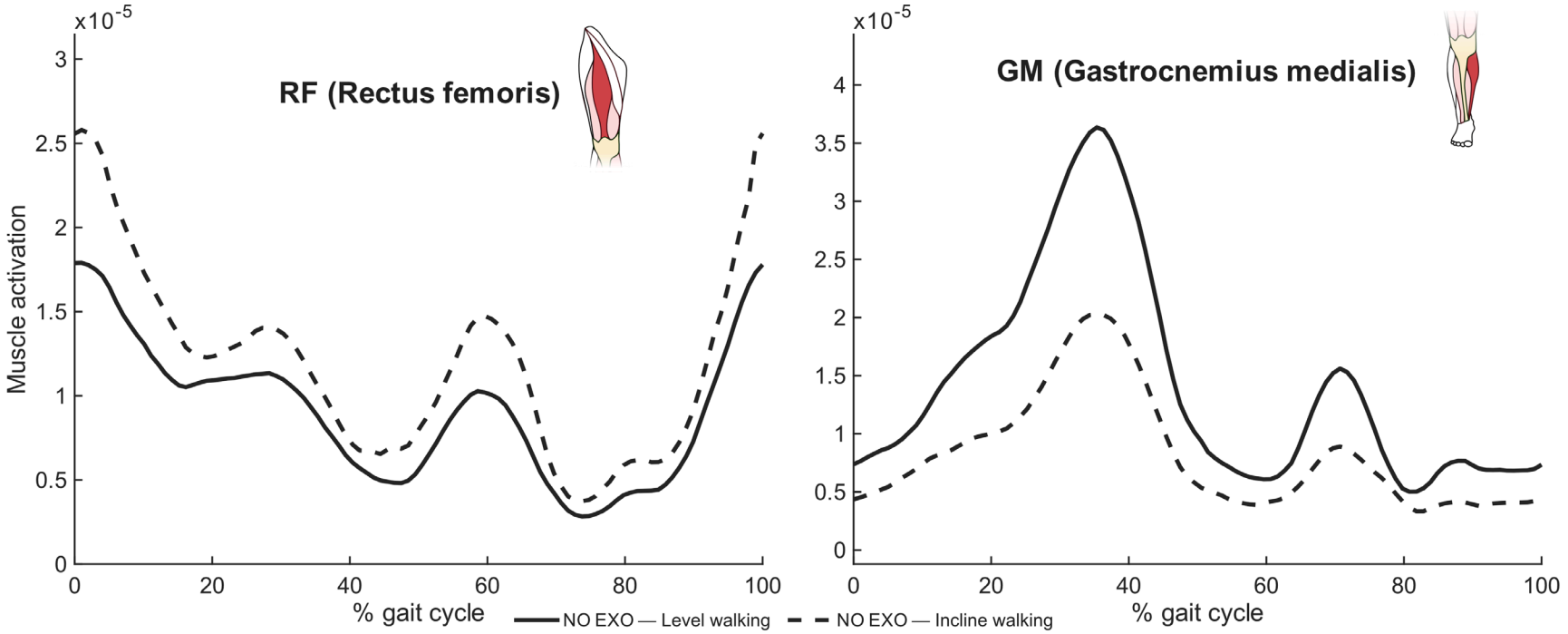
Prototype Assistive Exosuit: ASSIST-EX
Assistive SpaceSuit-Integrated SofT EXosuit



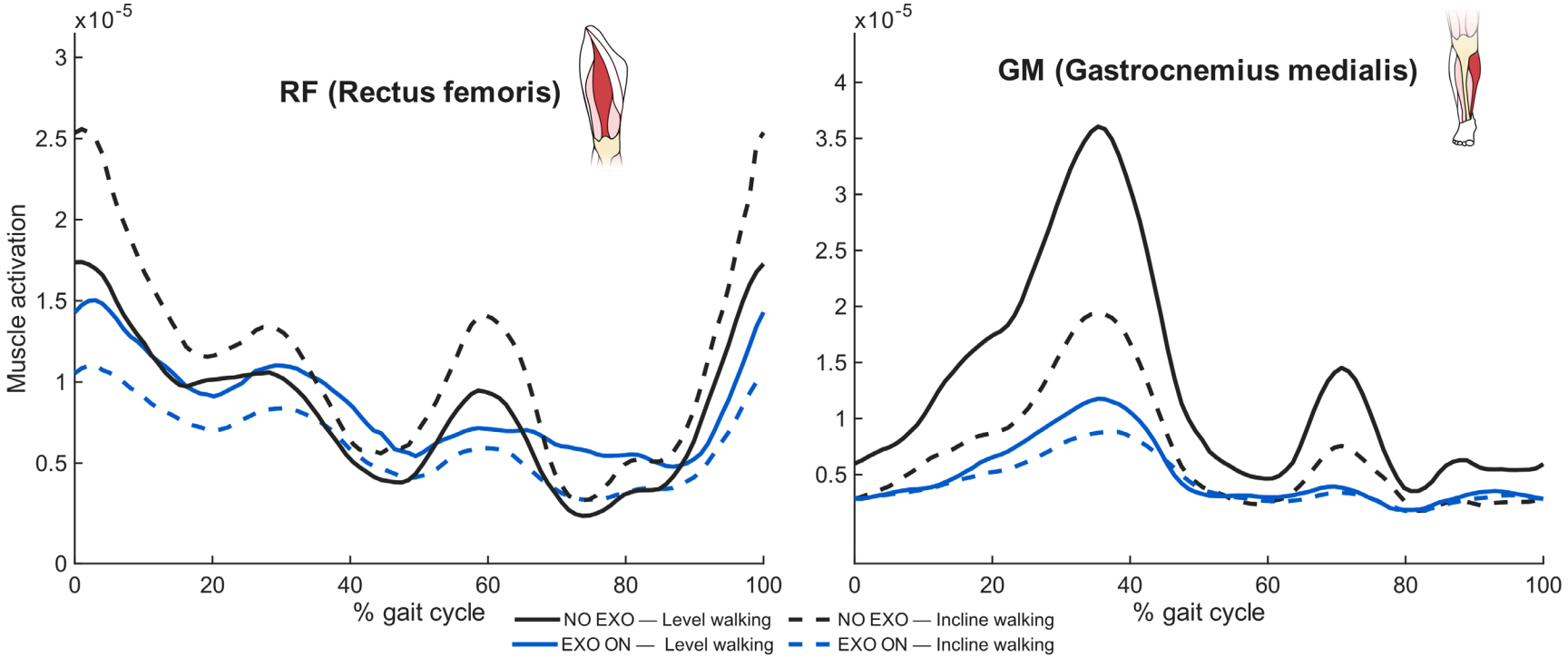
- Earlier work developed ***resistive*** exosuits to help astronauts maintain muscle mass in low gravity.
- Current work is now also developing ***assistive*** exosuits for supporting independent living.
- ***Lightweight***, compliant design (total textile component weight is 0.9kg) preserves natural gait unlike rigid exoskeletons.
- ***Highly cost effective***: with a production cost under £1000, far below existing solutions.



Muscle activation without exosuit assistance



Adding exosuit assistance





TIME

NOV 7, 2025 7:08 PM GMT

Are Robot Pants The Future Spacesuit?

SCIENCE | SPACE

by Jeffrey Kluger
EDITOR AT LARGE

BBC

New spacesuit 'could help astronauts' mobility'

18 hours ago

Share Save

John Darvall, BBC Radio Bristol, Georgia Eadie, West of England and Onyi Ubadigha, West of England

SPACE.com

New 'exosuit' with artificial muscles could help astronauts explore the moon and Mars

News By Elizabeth Howell published November 10, 2025

"The hope is that this technology could pave the way for future wearable robotic systems that enhance astronaut performance and reduce fatigue during extravehicular surface activities."

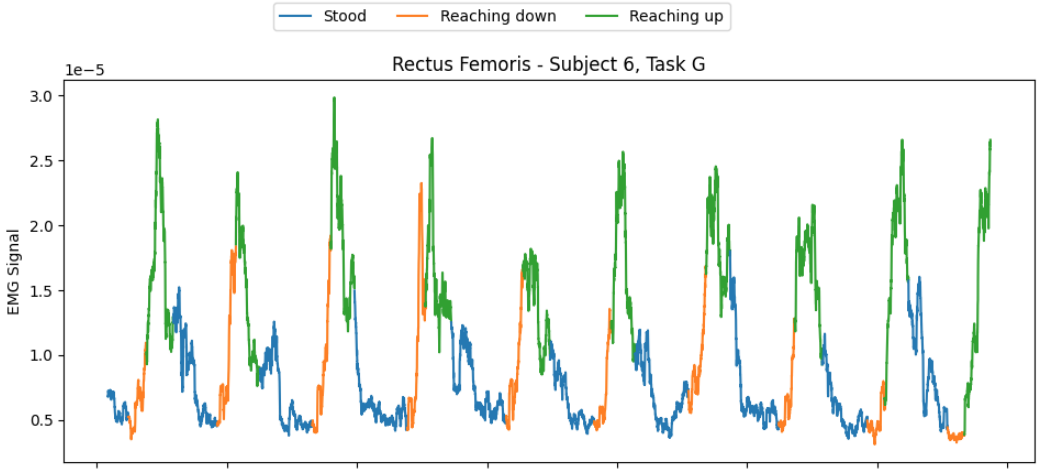
Future Research for Exosuit Development

- More efficient and portable actuation methods for moving artificial muscles
- Integrated wearable sensors and onboard compute (e.g. ***NVIDIA Jetsons***)
- Exosuit capable of supporting with other tasks e.g. sit to stand (***work under review***), fall prevention (***work in progress***)
- Adaptive assistance to facilitate rehabilitation
- Using Reinforcement Learning for exosuit control strategies

The Core Machine Learning Task

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- We want our model to take in Inertial Measuring Unit (IMU) and Electromyography (EMG) signal data (future work to integrate video data) and predict the label of the current frame given previous frames
- A prediction of the what the user is trying to do lets us actuate the exosuit to assist them in activities



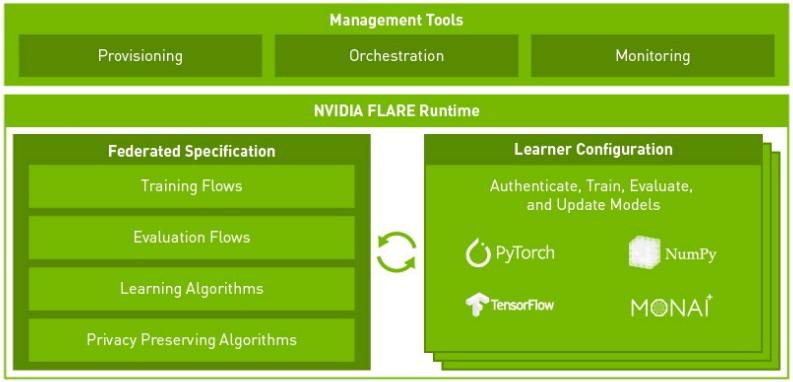
Model Requirements

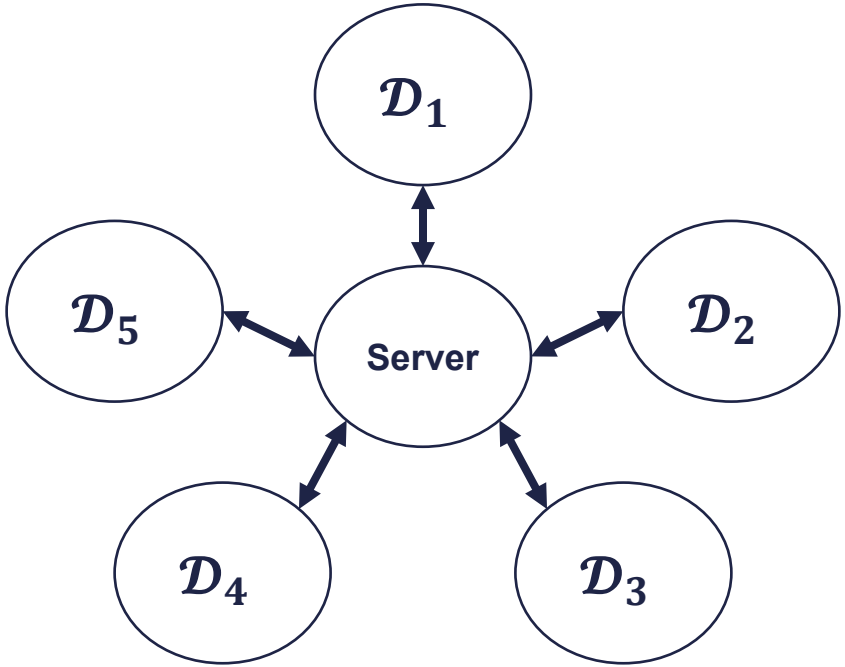
- Preserve ***privacy*** of user data
- Low ***latency*** and efficient ***inference***
- Limited access to ***labels***
- ***Adapt*** to changing movement patterns over time
- ***Personalise*** to individual movement patterns

Federated Learning

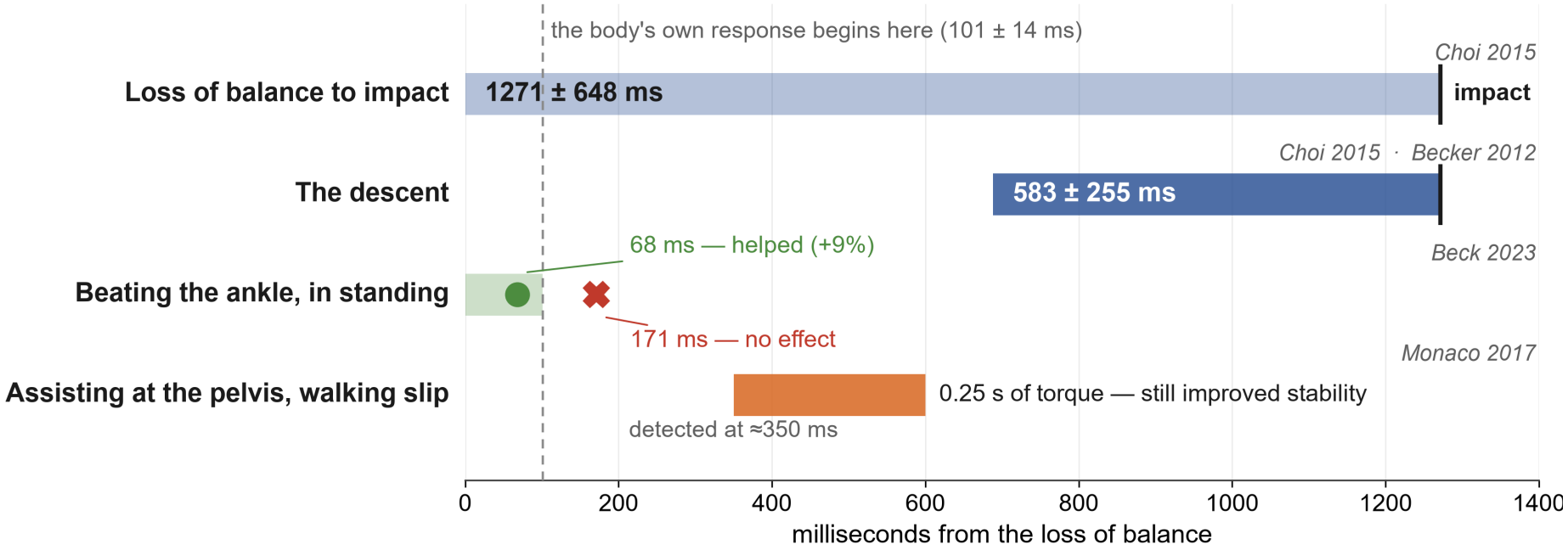
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- A key barrier to adoption is user trust that their data is being kept private.
- ***Federated Learning*** allows us to train centralised models on decentralised data by only sharing model updates.
- NVIDIA open source software development kit Federated Learning Application Runtime Environment (***FLARE***) enables us to do this.





Fall detection: low latency / efficient inference



Once balance is lost, the useful window for intervention is about 100 ms at the ankle and 350 ms at the pelvis.

No Labels…some problems?

We can’t expect participants of VIVO to label all their data as we go, but we still want to make the most of the data that they have, even if it isn’t labelled.

Some approaches:

1. ***Representation learning*** on the clients, keep a subset of labelled examples centrally (e.g. label data collected from VIVO researchers)
2. Learn from ***label proportions*** for each client (e.g. how much time does each person spend walking/sat down each day)

Evaluation in both cases becomes difficult because without instance level supervision, our proxy for accuracy becomes:

“Did the suit provide the required assistance at the required time?”

TACTFL: Temporal Contrastive Training for Multi-modal Federated Learning with Similarity-guided Model Aggregation

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Guanxiong Sun, Majid Mirmehdi, Zahraa Abdallah, Raul Santos-Rodriguez, Ian Craddock, Telmo de Menezes e Silva Filho (BMVC 2025)

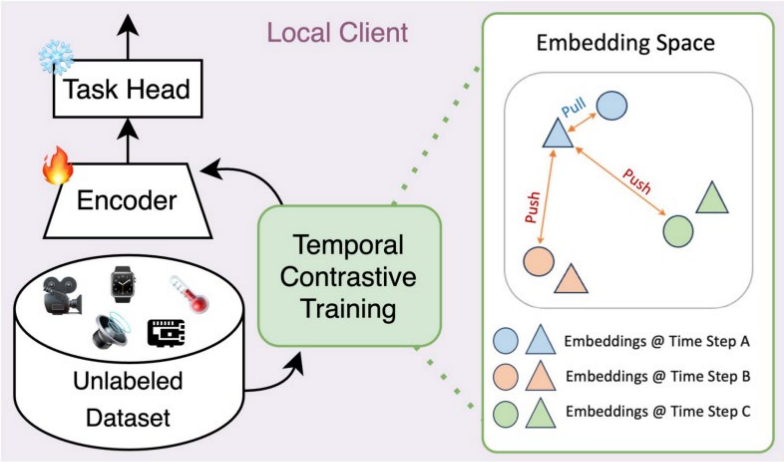


Figure 1(a). A conceptual overview of TACTFL. On each client, encoders are updated using temporal contrastive training (TCT) on unlabelled multi-modal data, while task heads remain frozen. The objective encourages embeddings from different modalities at the same time step to be pulled together in the feature space, and embeddings from different time steps to be pushed apart.

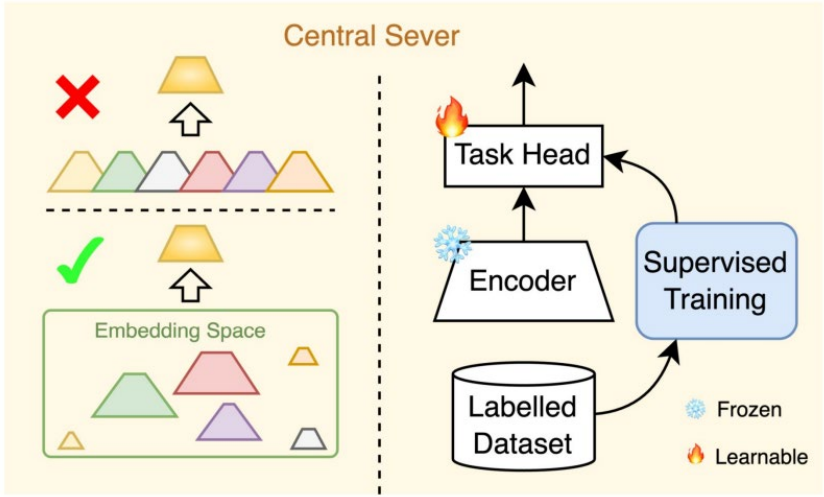


Figure 1(b). Unlike FedAvg, TACTFL adaptively weights each client model based on representational similarity. The server trains the task head on a small labelled dataset with frozen encoders.

Binary Classification from Multiple Unlabeled Datasets via Surrogate Set Classification

Nan Lu, Shida Lei, Gang Niu, Issei Sato, Masashi Sugiyama Proceedings of the 38th International Conference on Machine Learning, PMLR 139:7134-7144, 2021.

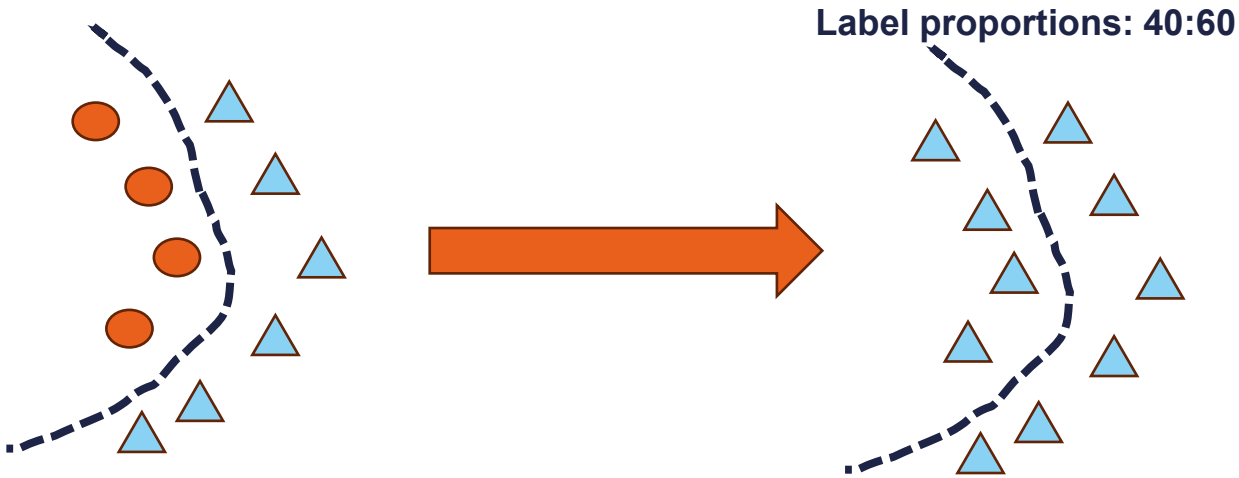
(ICML 2021)

FEDERATED LEARNING FROM ONLY UNLABELED DATA WITH CLASS-CONDITIONAL-SHARING CLIENTS

Nan Lu[1] Zhao Wang[2] Xiaoxiao Li[3] Gang Niu[4*] Qi Dou[2] Masashi Sugiyama[4,1]

(ICLR 2022)

- Previous work has demonstrated the possibility of binary classification with label proportions.
- This has since been extended to multi-class classification in a Federated setting.
- This work is robust to noisy class priors, e.g. “user spent about 60% of their day walking”



Adapting across People and over Time

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A model well calibrated to:

A person starting rehab

A person with typical locomotion

A person whose muscles typically activate before they move

might be poorly calibrated to:

The same person after 6 months of rehab

A different person with atypical locomotion (e.g. a limp, frail, uses a walking stick)

A person who experiences muscle spasms even when idle

We need machine learning models that can adapt and personalise for different groups of people and across different time points!

Transfer learning with limited labels

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- In both TACTFL and FedUL, a steady stream of features means we have some ability to adapt to a change in feature distribution (e.g. if a user varies what activities they do week to week).
- In TACTFL, supervision comes from the central server, which means a steady stream of labelled instances would likely be required to keep up with drift across clients.
- In FedUL, label proportions are needed up front for each client but it's possible for label drift to be masked, even when we have label proportions.
  - Our ***work under review*** suggests that structured bags are better for detecting drift but harder to learn from.





vivo

Thank you for listening!

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