**Slide 1: Title**

Good morning, thank you for the opportunity to speak today. My name is Tye Cameron, and I’m grateful to share my background, key project experiences, and why I believe the John Brian Roberts Studentship is the ideal next step in my journey toward a research career in human-robot collaboration.

**Slide 2: Academic Background**

I’m about to graduate with a First-Class masters in Mechanical Engineering from Cardiff University. Throughout my degree, I have gravitated toward control, robotics, and computing, achieving my highest grades in modules like Digital Control and Object Oriented Computing.

In my third year, I studied abroad at the Korean Advanced Institute of Science and Technology. While most international students took three undergraduate modules, I chose to take five in total, including two graduate-level courses. This exceeded the normal load of even Korean home students.

My graduate modules included:

* **Introduction to Robotics** with Professor Hae-Won Park, known for his work on the MIT Cheetah and gait adaptation across challenging terrains;
* **Learning-Based Control** with Professor Jemin Hwangbo, developer of simulation-accelerated control methods for the ANYmal robot.

My chosen undergraduate modules focused on systems modelling, control, and the physical applications of AI. In the last photo you can see my midterm project for the latter was a maze-solving robot, graded through in-class time trials.

**Slide 3: Key Projects and Experience (Part 1)**

Let me start with the most intellectually formative experience: the reinforcement learning-based quadruped sumo challenge at KAIST. I was one of just 12 undergraduates admitted to a class of 35, which included 5 PhD and 18 Master’s students.

After initial coursework in value and policy iteration, I trained my ANYmal agent using infinite horizon Proximal Policy Optimisation. I used a curriculum learning method, rewarding the agent for certain contact dynamics with a training box. My aim was to simulate leap-attacks, and our grades were determined through the results of a simulated arena, where we scored points by toppling opponents.

As shown in the first image, I placed 24th with grade B. Probably due to workload and time constraints, I didn’t manage to take many videos, but here’s the initial training process. The robot initiates a leap attack, being rewarded for contact velocity with the box and penalised and reset for contact with the arena ground. Later in the curriculum, rewards are given for proximity to the middle of the arena, and optimal centre of mass heights.

Next, the finite element solver. This was another simulation-focused project, where I implemented finite element theory to develop and optimise a custom 2D wing deformation solver in Python. I validated its accuracy against ANSYS and identified optimal material and geometric configurations by minimising stress and deformation, while maximising hardware utilisation.

**Slide 4: Key Projects and Experience (Part 2)**

The WalkAide wearable navigation system brought everything together: ROS, SLAM, and haptic feedback design based on cognitive science. I led the system integration, feedback and navigation algorithms, and I’m currently implementing EEG timestamps within the loop to monitor cognitive load during navigation.

One reason I chose the WalkAide project is that it was the only new initiative starting this year—as opposed to continuations of previous work. That sense of creative challenge was a key part of what drew me in.

Our interdisciplinary team had backgrounds in electronic, medical, and mechanical engineering. My strengths in Linux, Arduino, and control systems meant I led much of the system-level architecture and sensor integration logic.

And finally, while unrelated to robotics, my Bosch internship was a lesson in professionalism. My main contribution was the identification of suboptimal testing profiles that hid performance degradation. My solution saved upwards of 40% of the laboratory’s gas consumption. And further to this, I was trusted to identify hundreds of thousands of pounds in nonconformant parts. The provided trust and responsibility greatly benefited my confidence, but more than that, the manufacturing experience showed me that I crave the challenge of research and intellectual novelty.

**Slide 5: Motivation & Alignment**

Like many engineers, I want to leave a positive impact. But for me, this is quite personal.

I was born with a rare musculoskeletal condition that made walking uncertain until age 10 and my father also lives with a cognitive-motor disorder and I know first-hand the impact of assistive technologies—and the consequences of their absence.

That’s primarily why I chose the WalkAide project, and why I’m drawn to your research on shared autonomy and game-theoretic control. I want to work towards systems that are socially impactful and designed around human attributes. I think the WalkAide project really unlocked this ambition, and I only wish the project lasted longer this year, as you can see in this testing video, the APF algorithm and environmental perception system shows room to improve.

The Sussex HRI Lab stands out for values I deeply share: real-world applicability, interpretability, and inclusivity. It feels like the perfect place to start my research career.

**Slide 6: Future Vision**

Looking ahead, I want to develop systems that combine reinforcement learning with adaptive collaboration. I’ve always been excited by the modelling of human behaviour and preferences, so the combination of this with my technical passion for advanced robotic systems motivates my future contributions.

I’m particularly excited by your architectures that model user intent and confidence—including their desire to lead or follow. Inspired by your work, I want to explore game-theoretic negotiation of control authority and the use of fast, memory-efficient learning-based control for safe and intuitive human-robot collaboration.

I may be new to the research, but I’ve consistently sought out challenge, collaboration, and systems that matter. I’m ready to build on that foundation with your guidance, and in pursuit of technologies that genuinely improve human lives.

**Slide 7: Thank You**

Thank you for your time. I’m really excited by, and eager to contribute to Sussex HRI group research.

If you have any questions, like how my experience could fit within the laboratory’s scope, I’m very happy to discuss them.

CONTROL & OPTIMISATION CONCEPTS

Unconstrained MPC

* Refers to models without input, output, or state constraints (no inequality bounds).
* Simple and fast to solve, but can have unsafe implications in practice—important when human safety is involved.

Standard Least Squares

* Cost function that minimizes the sum of squared errors, just like in regression.
* Common in model fitting and trajectory tracking within MPC frameworks.

Persistent Excitation (PE)

* Ensures that an input signal is rich enough to explore all system modes.
* Necessary in adaptive control or system identification to ensure parameters converge.
* Also critical in learning-based systems to avoid underfitting dynamics.

Barbalat’s Lemma

* Used to prove asymptotic stability in nonlinear control.
* If a signal is bounded and its derivative is also bounded, and its integral is finite, then it converges to zero.
* Complements Lyapunov functions (which show stability but not necessarily convergence).

REINFORCEMENT LEARNING & CONTROL

Reinforcement Learning (RL)

* Mimics human learning through trial and error.
* Especially valuable when human behavior is non-rule-based or inconsistent.
* Allows customizable reward shaping (e.g., comfort, cognitive load).

PPO

* On-policy RL method for continuous control.
* Maintains infinite-horizon policy stability using a clipped objective, which is crucial in HRI to avoid unsafe jumps in behavior.
* Actor defines the policy, critic evaluates it.

MPC vs. RL

| MPC | RL |
| --- | --- |
| Requires a known model | Learns a model |
| Good for short-term safety | Good for long-term adaptation |
| Deterministic & interpretable | Flexible but data-hungry and less transparent |

Stochastic Policies

* Assign probabilities to actions → enables exploration.
* Helps reflect uncertainty or low confidence—wider action distributions indicate lower certainty.

QUADRUPED ROBOSUMO PROJECT

* Used sparse rewards: harsh penalties for touching the floor or leaving the arena.
* Stage 1 reward: trained a “leap attack” by rewarding intense force and high ground clearance.
* Curriculum shift: then incentivized stability — lower CoM, movement toward opponent, centering.
* Challenge: RL would discover a local minimum—resting against the box instead of engaging.
* Solution involved refining reward shaping and curriculum pacing.

CASE STUDY: WALKAIDE SYSTEM & DR. LI’S WORK

“I’d love to revisit the WalkAide system using your frameworks—for example, modeling user feedback as a latent state in a confidence-aware shared controller.”

* Observed user hesitation and error, which relate directly to control authority adaptation.
* Could use confidence inference to adaptively increase robot support when the user is struggling.
* Potential for selective communication — only send feedback when user is uncertain, saving bandwidth and avoiding overload.

SHARED AUTONOMY THEORY

Nash vs. Stackelberg Equilibrium

| Nash | Stackelberg |
| --- | --- |
| Simultaneous actions | Leader-follower dynamic |
| Stable mutual best responses | Robot leads unless human shows strong confidence |

Relevant to: negotiating control authority between human and robot in real-time.

Implementation Concepts

* Confidence Estimation: use Bayesian or game-theoretic inference from sensors.
* Control Arbitration: dynamically blend human and robot control based on confidence.
* Role Adaptation: modeled as Stackelberg game, updated in real-time.
* Learning Confidence-Aware Policies: via RL (e.g., PPO, SAC) with safety constraints.
* Model-Based Planning: learned dynamics can be plugged into MPC frameworks.

RESEARCH STYLE

“I’d describe my research style as iterative but increasingly strategic.”

* Began with fast-fail exploration, refined into goal-directed problem-solving.
* Learned during KAIST exchange that brute force can be inefficient without focus.
* Now uses selective prototyping — e.g., in WalkAide, identified near-fit systems and chose whether to adapt or abandon.
* In groups: assertive but collaborative — encourages parallel method testing, open to feedback.
* Takes pride in completeness and real-world viability of solutions.

PERSONAL VISION STATEMENT

“I’m especially interested in model-based reinforcement learning—a hybrid approach that combines the interpretability and safety of MPC with the adaptability of RL. This aligns closely with your future vision of building systems that update their models online to reflect human behavior.”

Li’s Work – Applied Summary Points

* Confidence-Informed Control Arbitration → adapt autonomy based on real-time inferred confidence.
* Learning Partner Preferences → RL that adapts policy based on user variability.
* Corrective Signal Learning → use human interventions as feedback to retrain or shift authority.
* Confidence-Weighted Communication → only share data (e.g. haptic feedback) when it is helpful or safe.

Li’s research progression

2014 – Latent Trajectory Estimation & Adaptive Impedance Control

* Paper: *Human–Robot Collaboration Based on Motion Intention Estimation* (IEEE/ASME T-Mechatronics) [pmc.ncbi.nlm.nih.gov+13researchgate.net+13scholar.google.com.sg+13](https://www.researchgate.net/publication/261601366_Human-Robot_Collaboration_Based_on_Motion_Intention_Estimation?utm_source=chatgpt.com)
* Methodology: Online neural-network (RBF/NN) based estimation of human-intended trajectory, integrated into adaptive impedance control.
* Strength: Interpretable, with Lyapunov-based stability guarantees. Enables the robot to actively follow human intent rather than passively comply.

2015 – Continuous Role Adaptation via Game-Theoretic Shared Control

* Paper: *Continuous Role Adaptation for Human–Robot Shared Control* (IEEE T-RO) [arxiv.org+5researchgate.net+5arxiv.org+5](https://www.researchgate.net/publication/261601366_Human-Robot_Collaboration_Based_on_Motion_Intention_Estimation?utm_source=chatgpt.com)[scholar.google.com.sg](https://scholar.google.com.sg/citations?hl=en&user=Sfi0b6wAAAAJ&utm_source=chatgpt.com)
* Methodology: Inference of human lead/follow intent through interaction forces and adaptive blending between human and robot commands.
* Strength: Smooth role adjustment grounded in game-theoretic principles, improving physical interaction safety and responsiveness.

2020 – Sensory Augmentation in Human–Robot Interaction

* Paper: *Improving Tracking through Human–Robot Sensory Augmentation* (arXiv) [www2.eecs.berkeley.edu+8arxiv.org+8arxiv.org+8](https://arxiv.org/html/2504.20761v1?utm_source=chatgpt.com)[arxiv.org+3arxiv.org+3arxiv.org+3](https://arxiv.org/abs/2002.07293?utm_source=chatgpt.com)
* Methodology: Kalman filtering of human control gains and desired trajectory; fusion with robot sensors.
* Strength: Transparent multi-agent perception, giving the robot access to human sensory feedback—leading to enhanced performance.

2022 – Editorial on Shared Control for Tele‑Operation

* Work: Editorial in *Frontiers in Robotics and AI* [arxiv.org](https://arxiv.org/abs/2002.07293?utm_source=chatgpt.com)[scispace.com+3frontiersin.org+3pmc.ncbi.nlm.nih.gov+3](https://www.frontiersin.org/articles/10.3389/frobt.2022.915187/full?utm_source=chatgpt.com)
* Focus: Advocated for advanced shared-control paradigms beyond simple leader–follower models, highlighting the importance of adaptive, bidirectional autonomy.

2025 – Confidence‑Based Intent Prediction for Surgical Tele‑Operation

* Paper: *Confidence-Based Intent Prediction for Teleoperation in Bimanual Robotic Suturing* (arXiv, April 2025) [scholar.google.com.sg](https://scholar.google.com.sg/citations?hl=en&user=Sfi0b6wAAAAJ&utm_source=chatgpt.com)[researchgate.net+4arxiv.org+4arxiv.org+4](https://arxiv.org/pdf/2504.20761?utm_source=chatgpt.com)
* Methodology: Multi-level intent prediction using transformer-based gesture recognition plus Bayesian confidence-weighted control.
* Strength: Data-driven, high-level surgical intent recognition with interpretable, confidence-directed shared control.

Most Successful Work

* The 2015 shared-control framework is widely cited and foundational—it has shaped practical thinking in adaptive role blending.
* The 2025 tele‑operation framework is Dr. Li’s latest work, showcasing cutting-edge intent modeling combined with safety via confidence weighting.

PhD Plan

I see the PhD as a staged process—first mastering and validating the foundations of confidence-aware shared control, then exploring how learning-based methods can adapt to individual user behavior in safe and explainable ways, and finally deploying and evaluating these systems in real-world interaction contexts. My goal is to contribute both technical methods and practical tools that improve how assistive robots collaborate with humans under uncertainty.

Year 1: Foundations, Reproduction, and System Setup

Goals:

* Build technical and theoretical depth in shared autonomy, nonlinear control, and human-robot interaction.
* Reproduce and study existing frameworks from Dr. Li’s previous work (e.g., confidence-aware blending, latent intent estimation).
* Identify gaps or limitations in those frameworks for future extension.

Activities:

* Conduct a literature review covering:
  + Game-theoretic modeling of human-robot interaction
  + Confidence estimation in intent-aware systems
  + Hybrid RL–MPC frameworks for safe learning
* Implement a baseline shared control framework in simulation (e.g., 2D or 3D assistive guidance).
* Develop a basic Bayesian confidence estimator and integrate it into control arbitration.
* Explore early prototypes of your WalkAide-inspired system using ROS + simulated human input.

Deliverables:

* Interim review or first conference short paper (e.g., ICRA or HRI workshop).
* Fully working simulation of confidence-aware shared controller.

Year 2: Original Contribution and Expansion

Goals:

* Propose and develop a novel method that extends current work in shared autonomy.
* Focus on learning from user behavior (e.g., via RL or imitation learning) to improve role adaptation and safety.
* Introduce or integrate model-based safety assurance into your shared control system.

Research directions (to be scoped with Dr. Li):

* Use RL (e.g., SAC or actor-critic) to learn a latent model of user intent or confidence over time.
* Fuse RL with MPC or barrier functions to enforce real-time safety despite learned policies.
* Extend shared control to multi-modal settings: e.g., using both joystick and gesture inputs.

Activities:

* Train and evaluate policies using PPO/SAC with confidence-weighted rewards.
* Test in realistic or semi-physical settings (e.g., simulator with user feedback or human-in-the-loop teleop).
* Formalize a Lyapunov-style or reachability-based safety analysis.

Deliverables:

* 1 journal or conference submission (e.g., T-RO, ICRA).
* Technical report outlining safety guarantees and observed policy behavior.

Year 3: Generalization, Real-World Testing, and Thesis Synthesis

Goals:

* Validate your proposed system across more general settings (e.g., unfamiliar users, cluttered environments).
* Improve interpretability and interface usability (e.g., confidence visualization, haptic feedback tuning).
* Complete the full contribution pipeline: theory → implementation → evaluation → explanation.

Activities:

* Run formal experiments (e.g., with user groups or controlled trials).
* Evaluate trade-offs: user preference vs robot autonomy, safety vs flexibility.
* Incorporate collaborative perception or multi-agent extensions if scope allows.

Deliverables:

* 1–2 conference or journal submissions based on full system.
* Write-up and structure of thesis chapters.
* Defense preparation and presentation of the contribution as an intelligent, adaptive autonomy framework for shared human-robot control.

**Slide 1: Title — *Confident, warm start***

**Good morning**, | and thank you for the opportunity to speak today.  
My name is **Tye Cameron**, | and I’m grateful to share my *background*, key project experiences,  
and why I believe the **John Brian Roberts Studentship** is the ideal next step  
in my journey toward a research career in **human-robot collaboration**.

*(Smile slightly. Let this land with a confident pause.)*

**Slide 2: Academic Background — *Grounded, proud but humble***

I’m about to graduate with a **First-Class master’s** in Mechanical Engineering from Cardiff University.  
Throughout my degree, I’ve naturally gravitated toward *control*, *robotics*, and *computing*,  
achieving my highest grades in modules like **Digital Control** and **Object-Oriented Computing**.

In my third year, I studied abroad at the **Korean Advanced Institute of Science and Technology**.  
While most international students took three undergraduate modules,  
I chose to take **five in total**, including two *graduate-level* courses—  
exceeding the normal load of even the Korean home students.

These graduate modules included:  
• *Introduction to Robotics* with **Professor Hae-Won Park**—  
known for his work on the MIT Cheetah and gait adaptation across difficult terrain.  
• *Learning-Based Control* with **Professor Jemin Hwangbo**,  
who developed simulation-accelerated control for the **ANYmal** robot.

And my chosen undergrad modules focused on *systems modelling*, *control*, and the *physical applications of AI*.  
And in the last photo—you can see the latter’s midterm project: a maze-solving robot,  
graded through **live in-class time trials**.  
*(Light smile here. Let it show your enjoyment.)*

**Slide 3: Projects & Experience (Part 1) — *Technically sharp, modest tone***

For my projects, let me start with the most *intellectually formative* experience:  
the **reinforcement learning-based quadruped sumo challenge** at KAIST.

I was one of just **12 undergraduates** admitted to a class of 35—  
which included 5 PhD and 18 Master’s students.

After coursework in *value* and *policy iteration*,  
I trained my **agent** using infinite-horizon **Proximal Policy Optimisation**.

I used **curriculum learning**, rewarding the agent for specific *contact dynamics* with a training box.  
The goal was to simulate **leap-attacks**,  
and our final grades were determined through **arena-style simulations**,  
where we scored points by *toppling opponents*.

As shown in the first image—I placed 24th with a Grade B.  
Probably due to time constraints, I didn’t capture many videos,  
but this clip shows the initial training phase.

You’ll see the robot **initiates a leap**, gets rewarded for *contact velocity* with the box,  
and is penalised and reset for *touching the ground*.

Later in the curriculem, rewards shift to proximity to the *arena centre* and optimal *Centre Of Mass height*.

The second project: a **finite element solver**—entirely built from scratch.  
I implemented **2D wing deformation** in Python, based on FEM theory,  
and validated its accuracy against **ANSYS**.  
I then optimised material and geometric configs—  
*minimising stress and deformation*, while *maximising hardware utilisation*.

**Slide 4: Projects & Experience (Part 2) — *Eager, ownership-driven tone***

Our **WalkAide** wearable navigation system brought everything together:  
ROS, SLAM, and haptic feedback, all grounded in *cognitive science*.

I led **system integration**, feedback design, and navigation algorithms—  
and I’m currently implementing **EEG timestamping** into the loop  
to monitor *cognitive load* during navigation.

One reason I chose this project?  
It was the **only new initiative** launching this year—  
i.e. not a continuation of previous work.  
The *creative challenge* really drew me in.

Our team combined electronic, medical, and mechanical engineering backgrounds.  
Thanks to my strengths in **Linux**, **Arduino**, and **control systems**,  
I led much of the **system-level architecture** and **sensor integration**.

And finally—my **Bosch internship**. While not robotics, it was a *real lesson in professionalism*.

My main contribution was identifying *inefficient testing profiles*  
that were hiding performance degradation.  
My solution reduced **over 40%** of the lab’s gas consumption.

I also gained the trust to flag and quarantine **hundreds of thousands of pounds** worth of nonconformant parts.  
That trust boosted my confidence and led to a job offer—but more importantly,  
the experience clarified that I *crave research*… and the challenge of *intellectual novelty*.

**Slide 5: Motivation & Alignment — *Personal, sincere tone***

Like many engineers, I want to leave a *positive impact*.

But for me—it’s *personal*.

I was born with a rare musculoskeletal condition,  
and it wasn’t clear I’d ever walk until around age **10**.

My father also lives with a **cognitive-motor disorder**,  
and I’ve seen first-hand the impact of *assistive technologies*—  
and just as clearly, the consequences of their **absence**.

That’s why I chose the **WalkAide** project.  
And why I’m drawn to your work in **shared autonomy** and **game-theoretic control**.

I want to contribute to systems that are both *socially impactful*  
and *built around real human attributes*.

I think this project **unlocked that ambition** for me.  
I only wish it had lasted longer.  
In this test video, you’ll see: the APF algorithm and environmental perception system  
still have **plenty of room to improve**.

What draws me most to the **Sussex HRI Lab**  
isn’t just the research—it’s the *values behind it*:  
a chance of real-world **impact**, **interpretability**, and **inclusivity**.

It feels like a place where I could really grow—  
and contribute to work that *means something*.

**Slide 6: Future Vision — *Forward-looking, confident***

Looking ahead—I want to develop systems that combine  
**reinforcement learning** with **adaptive collaboration**.

I’ve always been excited by the **modelling of human behaviour and preferences**,  
and combining that with *technical passion* for advanced robotic systems  
is driving me forward.

Your work really resonates—especially the architectures  
that model **user intent and confidence**,  
including the user’s *desire to lead or follow*.

Inspired by this, I want to explore **game-theoretic negotiation of control authority**,  
and fast, **memory-efficient learning-based control** for safe, intuitive interaction.

I’m particularly interested in how your frameworks could guide future development—  
both *conceptually*, and through **practical implementation**.

My current vision is still *deliberately broad*—  
and I’d really value the chance to **refine and shape it under your mentorship**.

I may be new to formal research—but I’ve consistently sought out  
**challenge**, **collaboration**, and complex systems that *matter*.

I’m ready to build on that—with your guidance—  
in pursuit of technologies that *genuinely improve people’s lives*.

**Slide 7: Thank You — *Grateful, calm finish***

Thank you for your time.

I’m genuinely excited by the opportunity to contribute  
to the **Sussex HRI group**.

If you have any questions—especially about how my background might fit  
within the lab’s research goals—I’d love to discuss them.