UFMG
UNIVERSIDADE FEDERAL
DE MINAS GERAIS

Robótica Móvel

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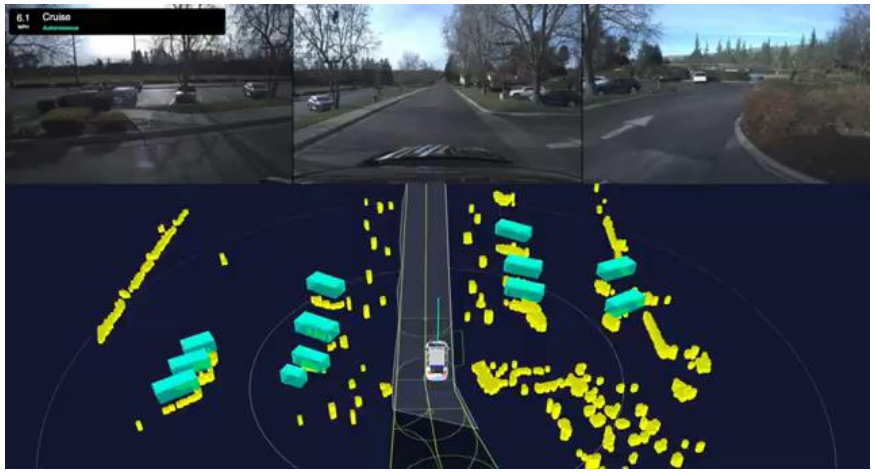
DCC
DEPARTAMENTO DE
CIÊNCIA DA COMPUTAÇÃO

VERLab
Visão e Robótica

Sobre o que é esse curso?



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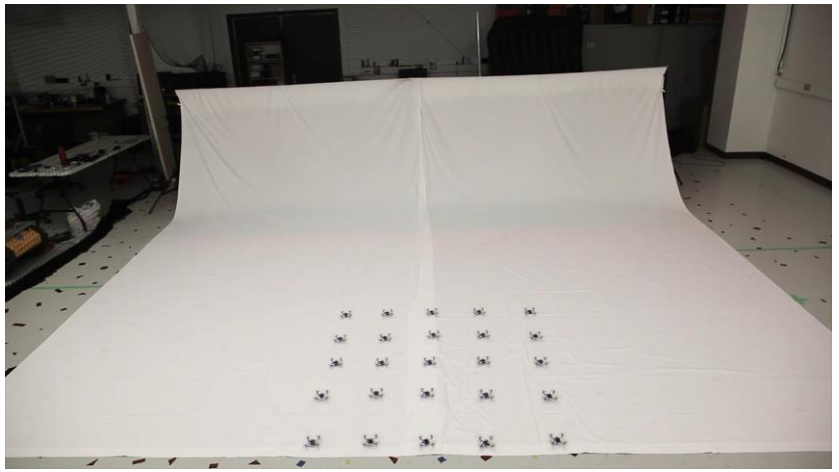

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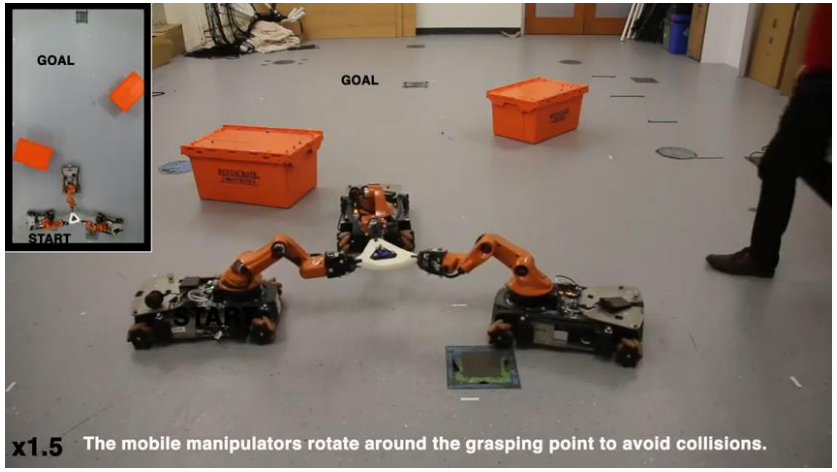

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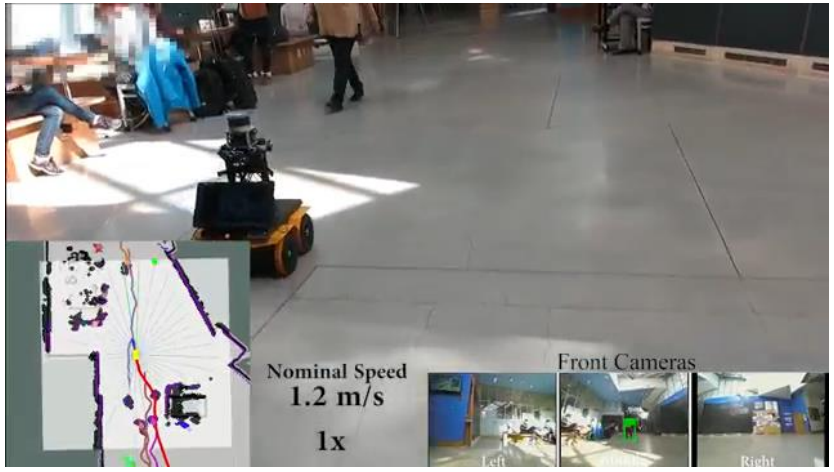

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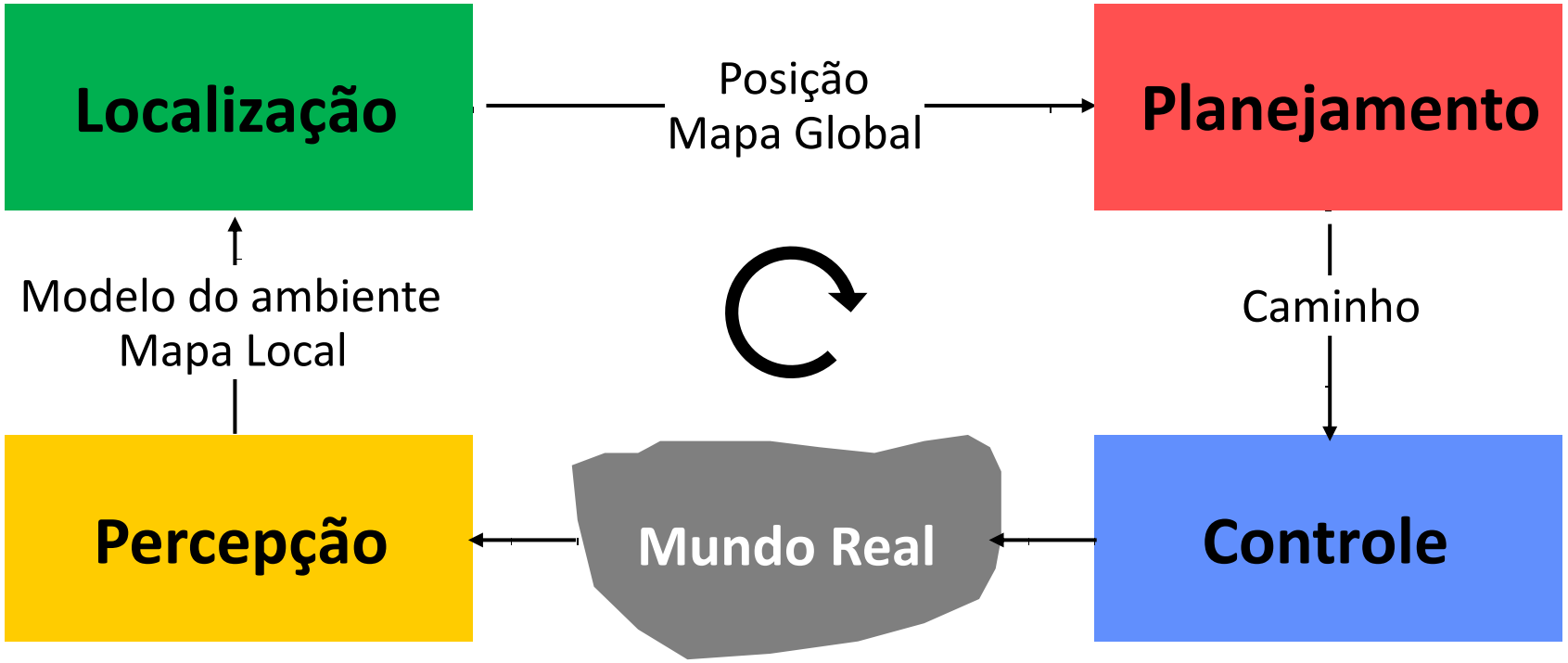
Objetivos do curso

Esta disciplina abordará os principais conceitos da **Robótica Móvel**. Serão vistos aspectos relacionados a **locomoção**, **navegação**, **planejamento de caminhos**, **percepção**, **localização** e **mapeamento**. Ao final, os alunos devem ser capazes de **entender esses conceitos**, bem como **implementar pequenas aplicações** em simuladores e plataformas robóticas reais, além de prosseguir no desenvolvimento de projetos de pesquisa.

Conteúdo abordado



Conteúdo abordado

- História e Atualidades
- Descrição espacial e transformações
- Locomoção / Controle
- Paradigmas robóticos
- Planejamento de caminhos
- Localização / Mapeamento / SLAM
- Sistemas multi-robôs

Bibliografia

Básica

- **Introduction to Autonomous Mobile Robots.**
  Roland Siegwart, Illah Reza Nourbakhsh & Davide Scaramuzza.
  The MIT Press, 2011. 2nd Edition.

- **Probabilistic Robotics.**
  Sebastian Thrun, Wolfram Burgard & Dieter Fox.
  The MIT Press, 2005.

Bibliografia
Complementar

- **Robótica.**
  John J. Craig.
  Pearson, 2013. 3a Edição.
- **Planning Algorithms.**
  Steven M. LaValle.
  Cambridge University Press, 2006. (online)
- **Computational Principles of Mobile Robotics.**
  Gregory Dudek & Michael Jenkin.
  Cambridge University Press, 2010. 2nd Edition.
- **Principles of Robot Motion: Theory, Algorithms, and Implementations.**
  Howie Choset, Kevin M. Lynch, Seth Hutchinson, George A. Kantor, Wolfram Burgard, Lydia E. Kavraki & Sebastian Thrun.
  A Bradford Book 2005.

Moodle

- **Todas** as informações do curso
  - Avisos
  - Vídeos
  - Notas de aulas
  - Atividades práticas
  - Discussão de dúvidas

Critérios de avaliação

- **Provas** (2x15): 30pts
- **Trabalhos práticos** (8+14+16): 38pts
- **Projeto final**: 32pts

Critérios de avaliação

- Provas
  - Conteúdo visto durante a aula
  - Material de referência (slides, livros, etc.)
  - Exercícios
- Revisão da correção
  - Em até uma semana após divulgação da nota
- Em caso de falta
  - Justificativa em até 48 horas após data de realização
  - Outra avaliação será dada ao final (todo conteúdo!)

Critérios de avaliação

- Trabalhos Práticos
  - Código
    - Funcionamento, aplicação dos conceitos, ...
  - Documentação
    - Clareza e coesão, conteúdo, ...
  - Em alguns casos pode ocorrer entrevista

- Projeto Final: Tema livre, já comece a pensar em algo!

Honestidade acadêmica

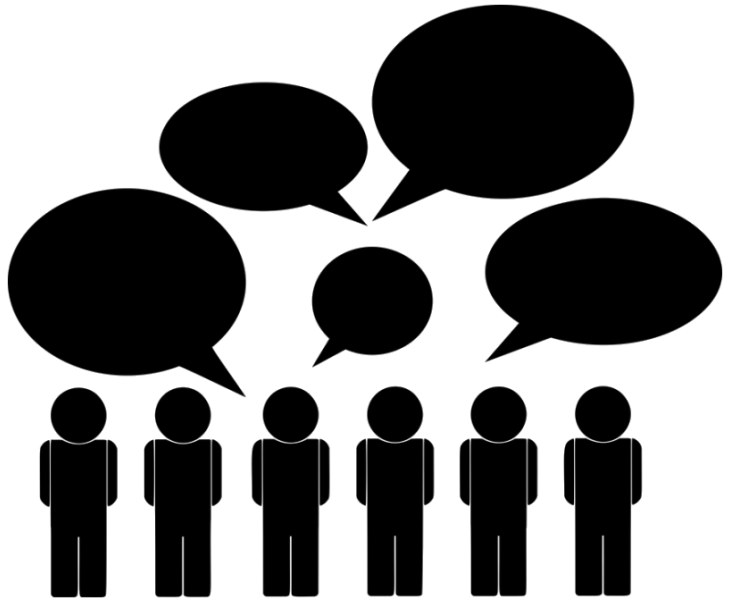
- Haverá tolerância **ZERO** com cópia/cola
  - Nota da atividade será automaticamente anulada
  - Poderá ser aberto processo disciplinar no colegiado

Compartilhe dicas e sugestões,
mas **não compartilhe código**!

Participação

- Lista de presença em todas as aulas

- Por que devo participar?
  - Tirar dúvidas (suas e de colegas)
  - Colaborar com discussões em sala
  - Dicas sobre possíveis questões
  - Mencionar algo não contido nos slides



Lembre-se, são roteiros de aula e não uma apostila!

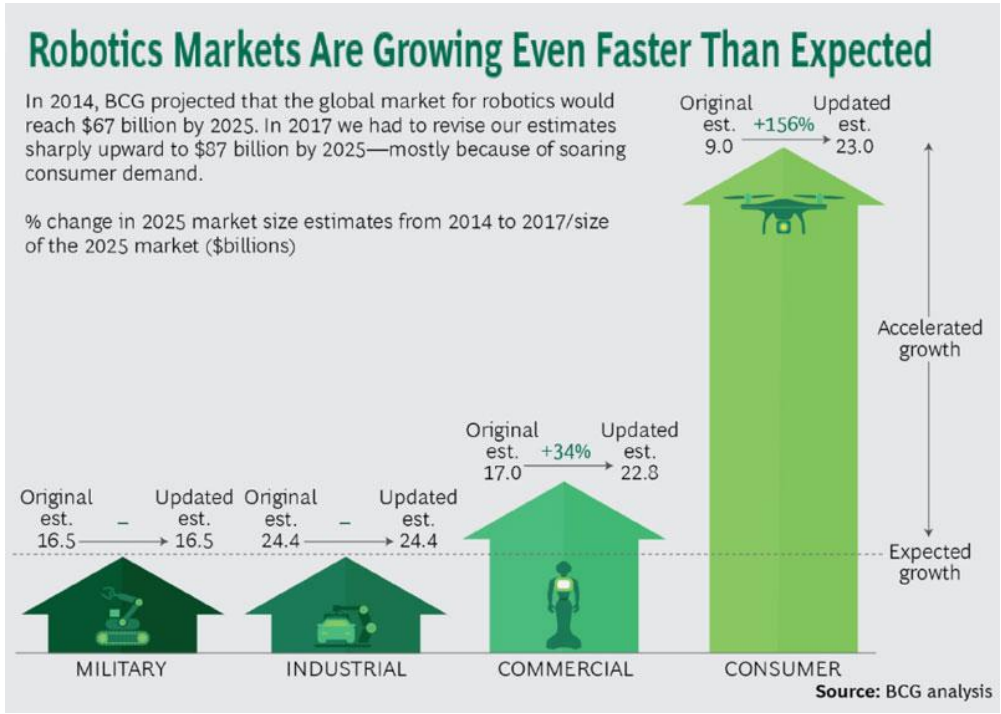
Contato

- Email: casos especiais ou de cunho particular
  - douglas.macharet@dcc.ufmg.br
  - Adicionar no assunto: **[DCC042]**

- Sala:
  - ICEx – 4314 (Anexo U)
  - Agendar um horário por email

Motivação

- Papel cada vez mais relevante
- Utilização em diversas tarefas
  - Manipuladores: setor produtivo
  - Robótica móvel: onde?
- Próximo "computador pessoal"?



https://www.therobotreport.com/robotics-industry-growing-faster-than-expected/

Motivação

What Can I Do with an MS in Robotics: 7 Careers Defining the Industry

By Ashley DiFranza | October 14, 2020

7 Top Careers in Robotics

Padir explains that "robotics is a very interdisciplinary field, and robots are tightly integrated systems." For this reason, there is an array of niche careers that fall under the general umbrella of robotics, each of which contributes to the development of these autonomous machines.

Below, we explore seven of the top careers defining the robotics industry today.

1. Design Engineer

Average Salary: $68,296 per year

Design engineers create the visual look of a robot. They often start by sketching blueprints, schematics, or figures of a robot's intended design, then work with a mechanical engineering team to ensure those plans are followed correctly during development.

Though their work is concerned with the physical appearance, proportions, and functions of a robot, it is also important that design engineers have advanced computer science knowledge and that they understand how the various components of their design work together to bring a machine to life.

2. Software Engineer

Average Salary: $86,016 per year

Software engineers in robotics are in charge of developing the software that allows each machine to function. They work closely with software designers and programmers to integrate new software with existing systems and typically remain involved throughout the robot's construction to ensure full functionality is achieved.

In robotics, software engineers are also tasked with staying up-to-date with changing technologies and trends, and must apply updates or reconfigure existing robotics software as needed.

3. Hardware Engineer

Average Salary: $87,556 per year

A hardware engineer is responsible for the computer hardware that robots utilize to function. They can have a hand in everything from prototyping to development, and are often tasked with overseeing the execution of a hardware build.

Once a robot has been constructed, a hardware engineer may also partake in testing and analysis of the designed systems, and lead a team in making any necessary changes for improvement.

4. User Experience (UX) Designer

Average Salary: $105,096 per year

The work of a UX designer is one aspect of robotics Padir considers integral but often underrepresented in the larger robotics field. When building a robot, "sometimes engineers can overlook what the user needs," he explains, identifying that it is up to the UX designer to represent this perspective in the development process.

These professionals are typically tasked with evaluating how consumers will interact with a robot, and making decisions about how to build a system that's best equipped to meet those needs.

5. Data Scientist

Average Salary: $105,750 to $180,250 per year

As most robots run on data, the work of a data scientist is critical within the robotics field. These professionals are responsible for designing data modeling processes and creating the algorithms and predictive models on which the data is gathered and interpreted. They also analyze data sets on which existing robots function, make adjustments to collection processes or storage systems, and measure effectiveness in order to improve functionality.

6. Machine Learning Engineer

Average Salary: $111,627 per year

Machine learning engineers are responsible for the automation aspect of robotics. These professionals rely heavily on data and predictive analytics in their work. In many cases, they use advanced software to automate predictive models as a way of advancing the machine's function and helping it "learn" from its experiences.

Machine learning engineers are often highly skilled in data science, deep learning, natural language processing, programming, and more.

7. Algorithm Engineers

Average Salary: $121,500 per year

In the scope of robotics, an algorithm engineer's main role is to research, develop, and then test the algorithms on which a robot runs. These professionals work closely with the rest of the development team to understand the desired functionality of the robot, then identify and integrate the data needed to reach that goal.

This role straddles the line between data science, software, and computer science, requiring professionals to be well versed in all three disciplines.

Fonte: https://www.northeastern.edu/graduate/blog/robotics-careers-what-can-i-do-with-an-ms-in-robotics/

Definição

- O que é um robô?

> "A robot is a reprogrammable **multifunctional manipulator** designed to **move material, parts, tools, or specialized devices** through **variable programmed motions** for the performance of a **variety of tasks**."
>
> – Robot Institute of America, 1979

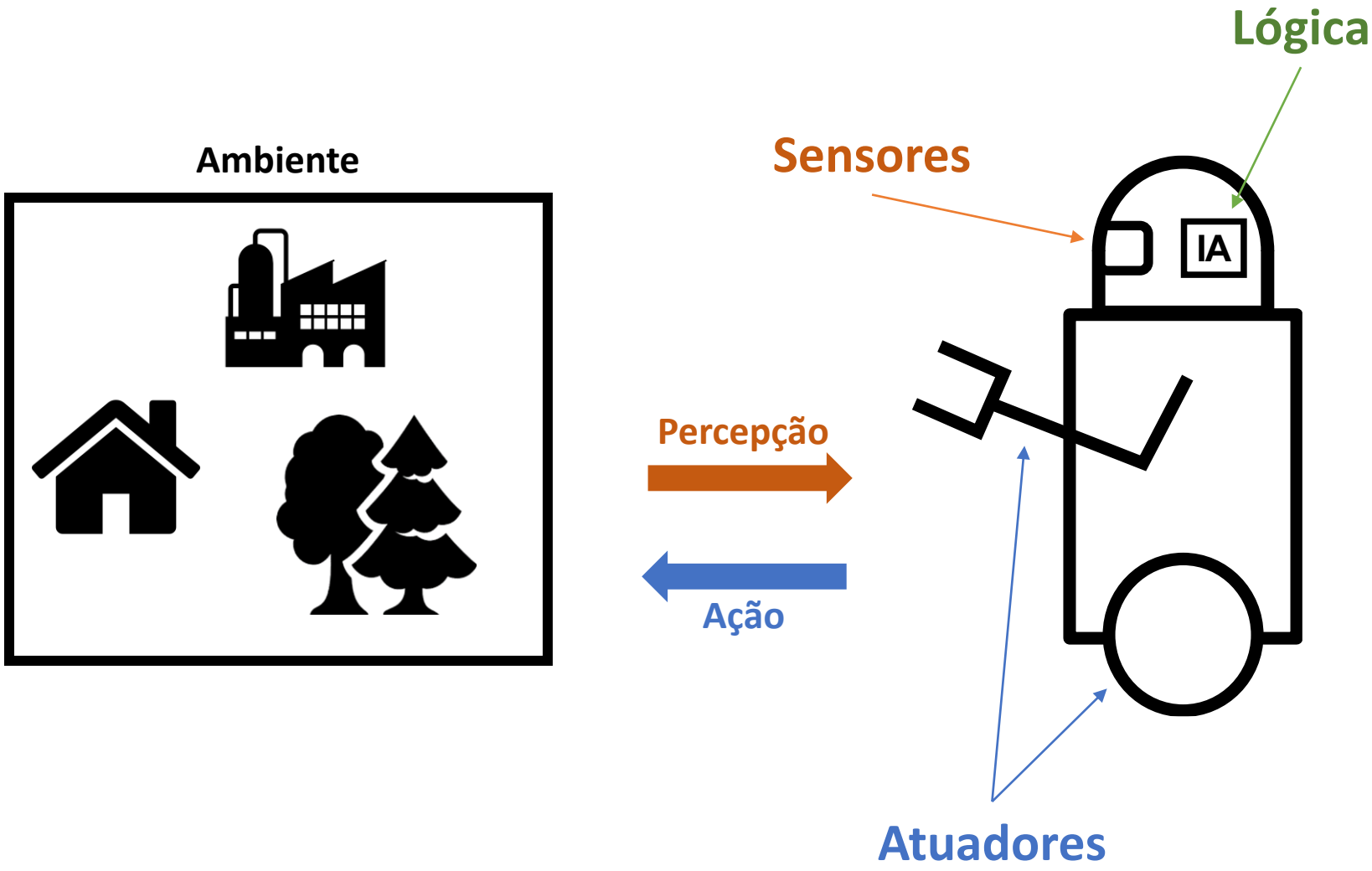
Definição

- O que é um robô?

> “I can’t define a robot, but I know one when I see one.”
>
> – Joseph Engelberger

The Father of Robotics: https://www.robotics.org/joseph-engelberger/about.cfm

Agente inteligente



Automação vs. Robótica

- **Automação**
  - Robôs de produção
  - Ambientes estruturados
  - Percepção e decisão limitadas
  - Células de Manufatura

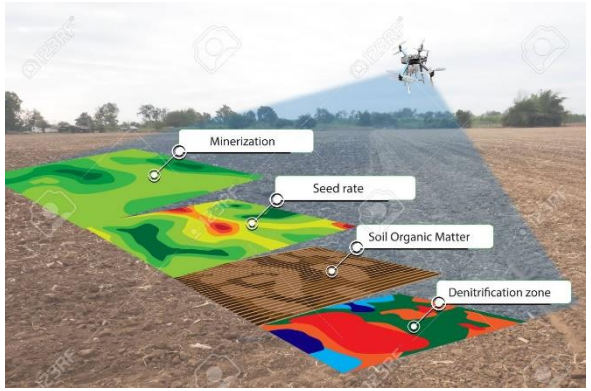
- **Robótica**
  - Robôs de *exploração*
  - Ambientes não estruturados
  - Diferentes sensores
  - Vários ambientes

Fonte: https://unisig.com/news-and-events/technical-articles/full-auto-barrel-automation-cell
Fonte: https://www.mercurynews.com/2018/04/16/sidewalk-robots-smacked-down-in-s-f-coming-to-san-jose-company

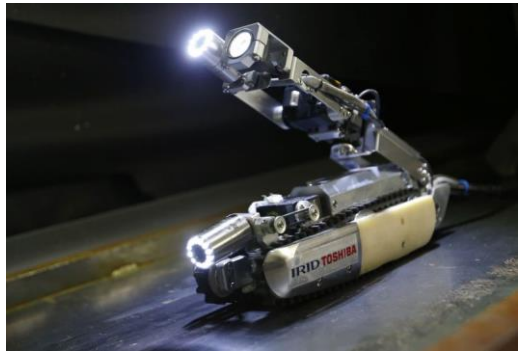
Robótica Móvel

Exemplos de aplicações

Agricultura



Inspeção

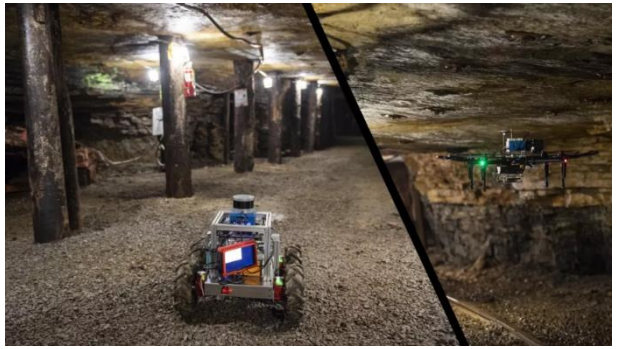


Entregas

Hospitais

Monitoramento

Mineração



Robótica Móvel

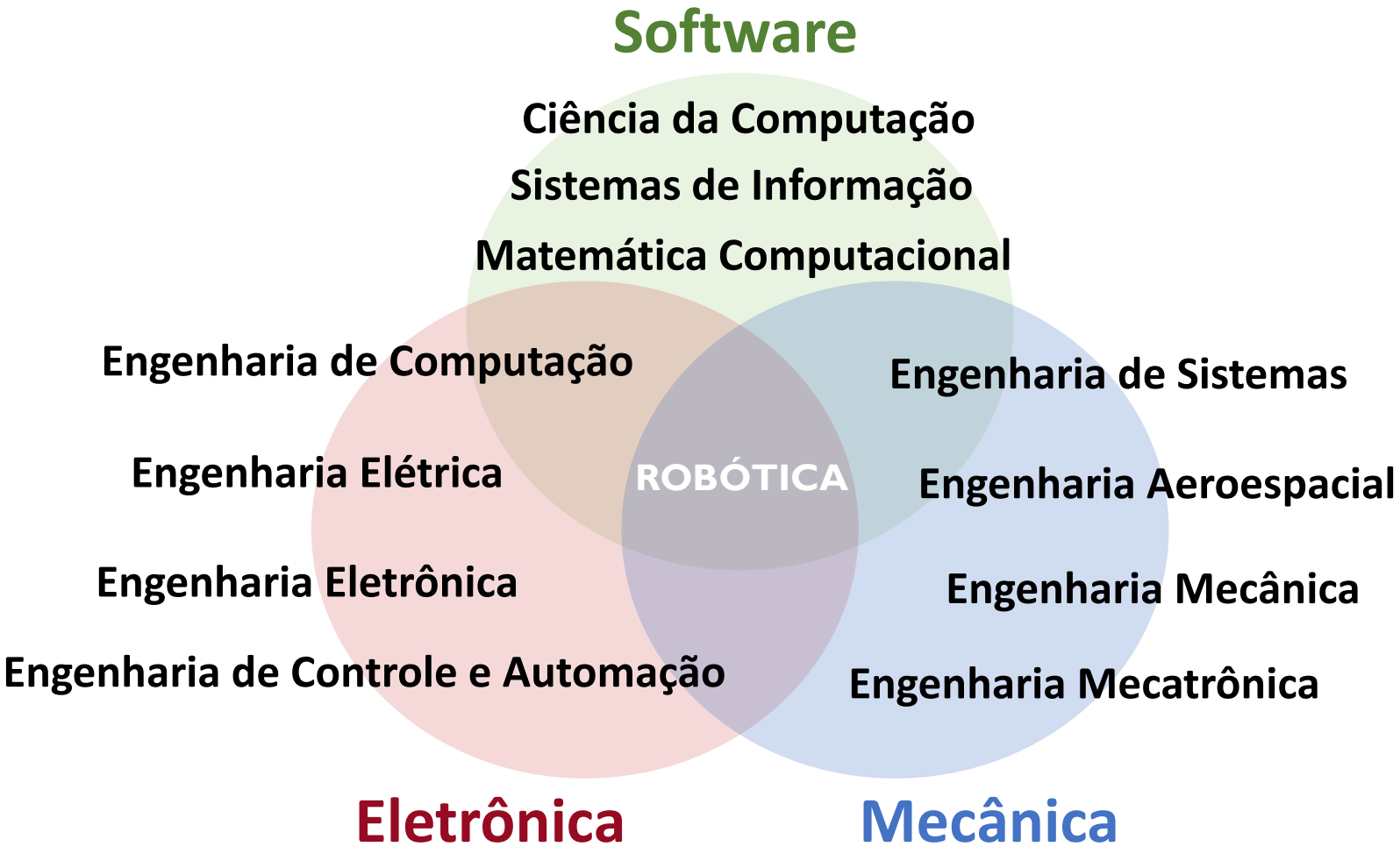
Multidisciplinar

- **Básicas**
  - Física, Matemática, Biologia, ...

- **Avançadas**
  - Cálculo, Álgebra linear, Probabilidade, …
  - Algoritmos, Estruturas de Dados, Otimização, ML,…
  - Controle, Processamento de sinais, Estruturas, …
  - Psicologia, Sociologia, Ética, …

Robótica Móvel

Interdisciplinar



Robótica Móvel

Áreas de pesquisa

- Locomoção
- Localização
- Mapeamento
- Planejamento de caminhos
- Navegação
- Controle

SLAM

- Aprendizado
- Robótica cooperativa
- Swarms
- Interação Humano-Robô
- Humanoides/Quadrúpedes
- Manipuladores móveis

⋮

Robótica na UFMG

- Laboratórios/Grupos
  - **DCC: Visão Computacional e Robótica (VeRLab)**
  - DEE: Sistemas de Computação e Robótica (CORO)
  - DELT: Mechatronics, Control, and Robotics (MACRO)

- Pesquisa e Desenvolvimento de Veículos Autônomos (PDVA)
  - DEE/DELT/DEMEC/DCC

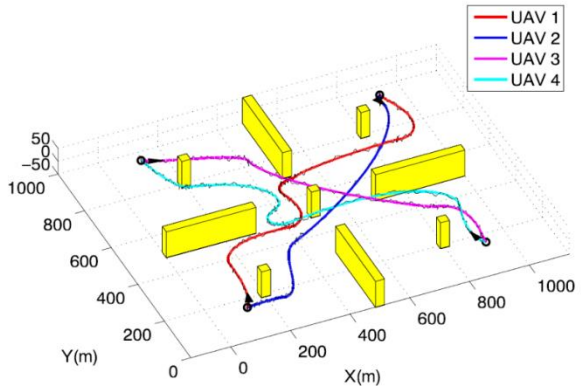
Robótica na UFMG

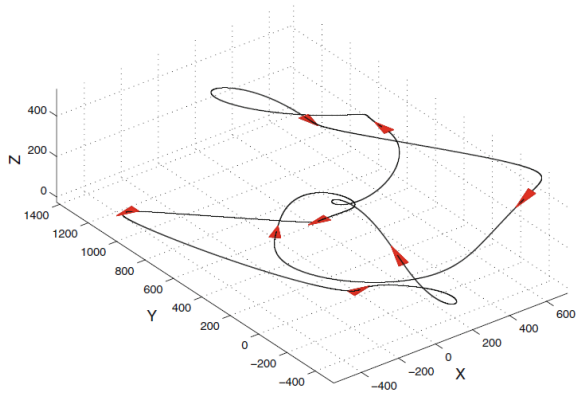
- Disciplinas DCC
  - Introdução à Robótica (G)
  - Robótica Móvel (G+PG)

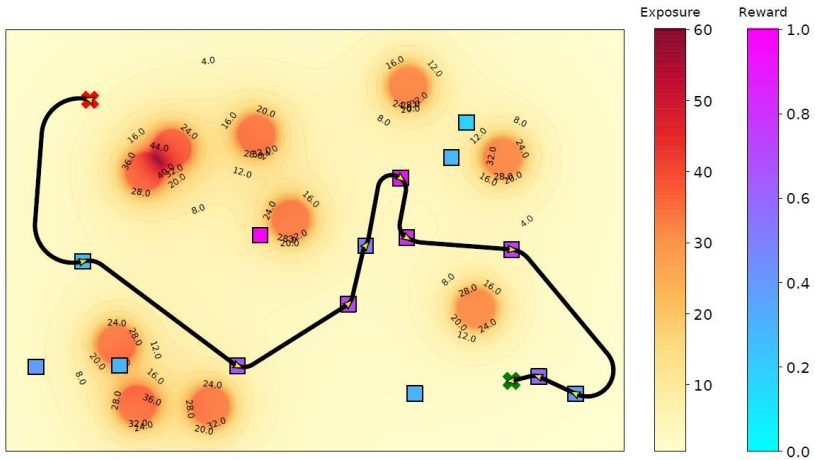
https://www.youtube.com/channel/UCj4uVyBifpc2BoDSUSagaXQ

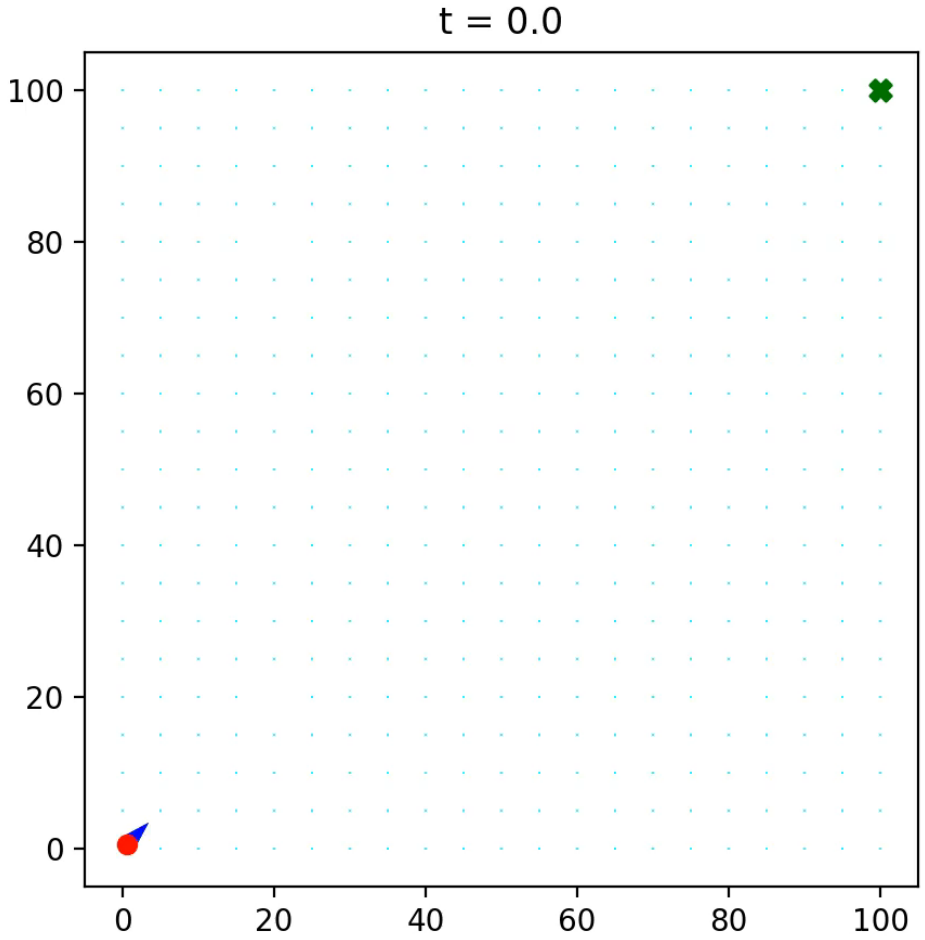
Robótica na UFMG

VeRLab: Planejamento de caminhos com restrições









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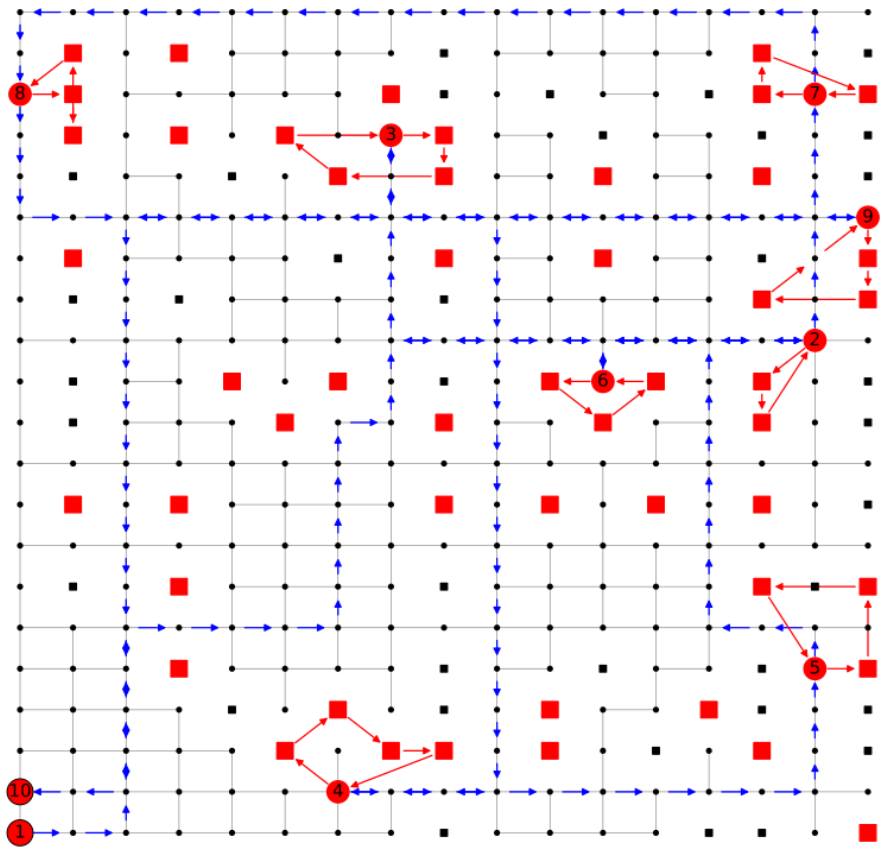
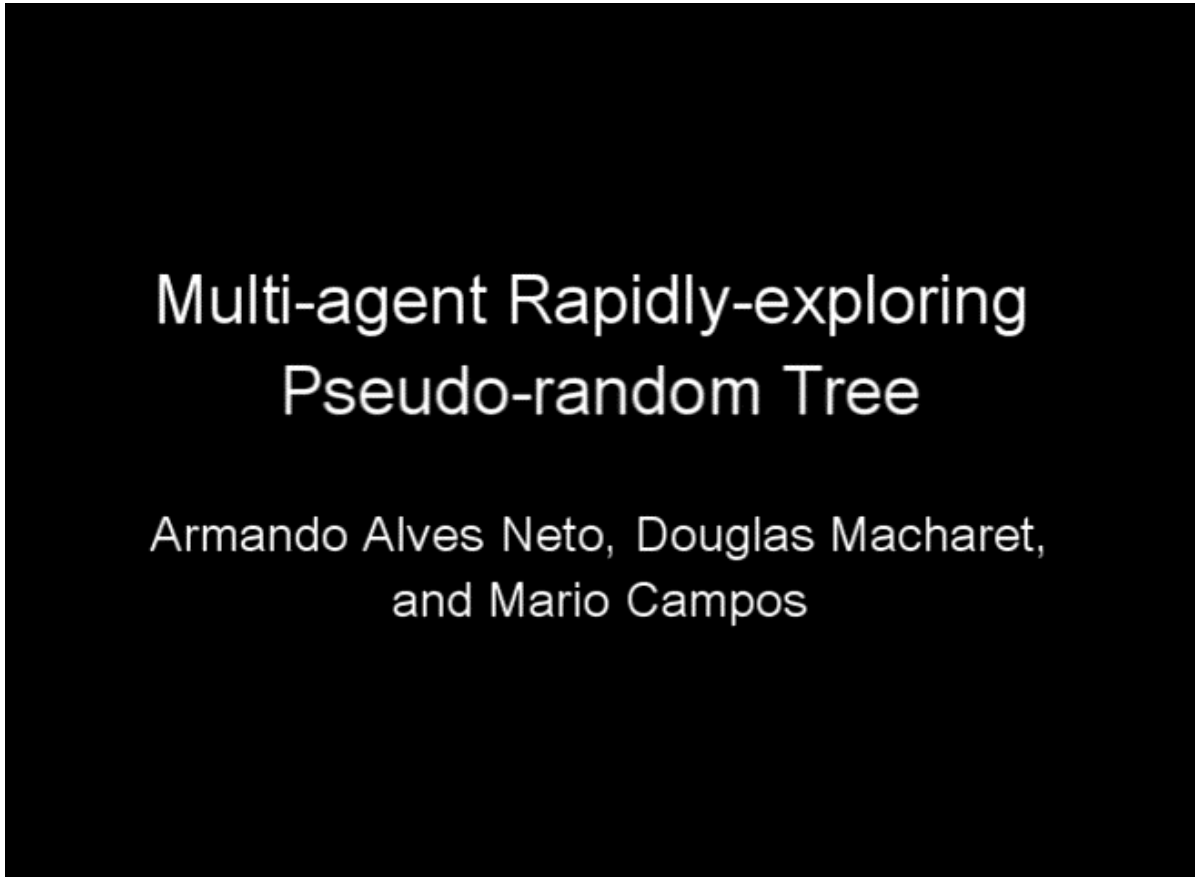
Robótica na UFMG

VeRLab: Planejamento de caminhos UAV/UGV



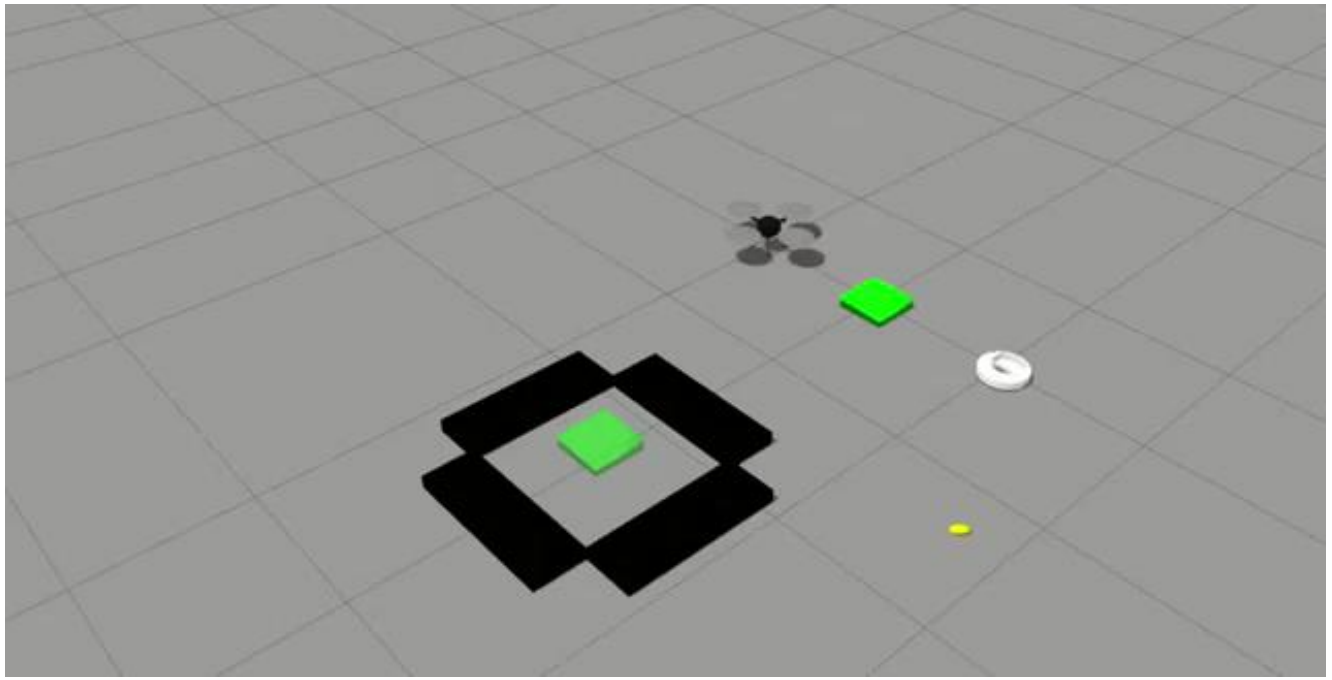


https://youtu.be/WwxIrwyu7aQ

Robótica na UFMG

VeRLab: Robótica cooperativa

https://youtu.be/RngrsRgYzwY



https://youtu.be/eGeQOFa_VQ4

Robótica na UFMG

VeRLab: Mapeamento aero-magnético

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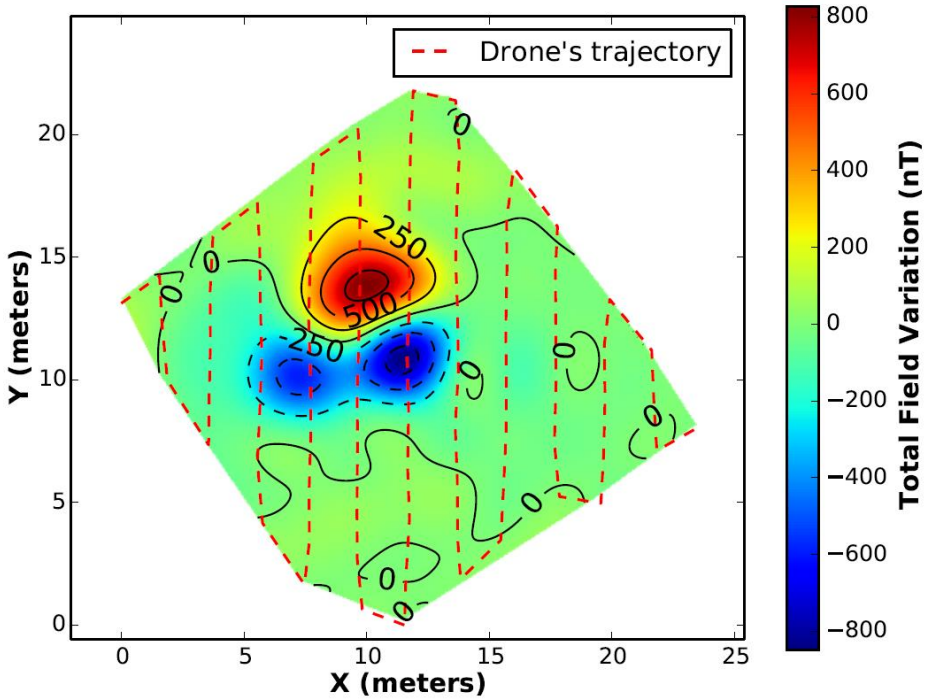
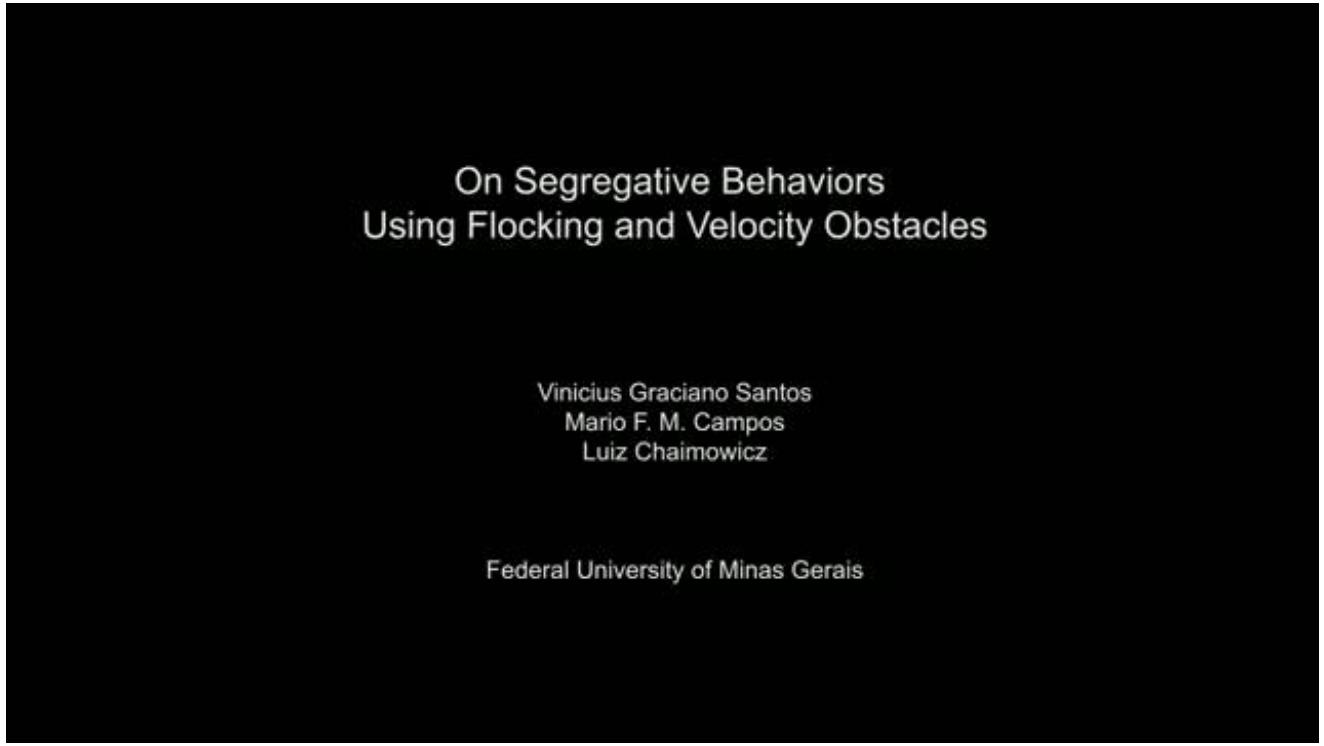


Robótica na UFMG

VeRLab: Swarms



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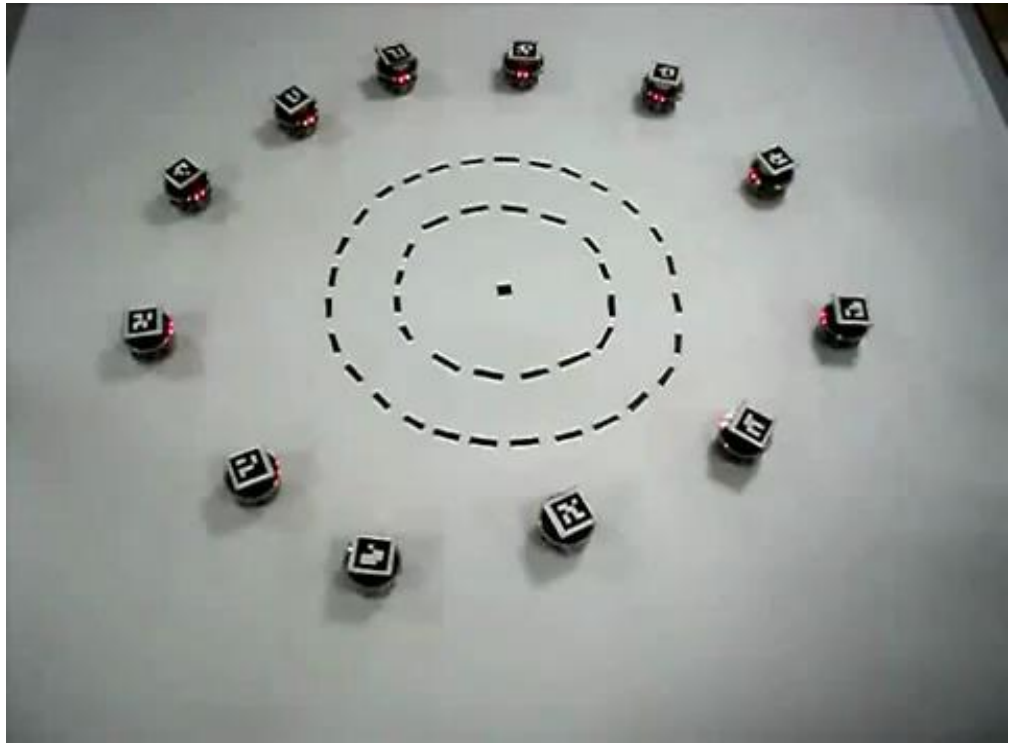
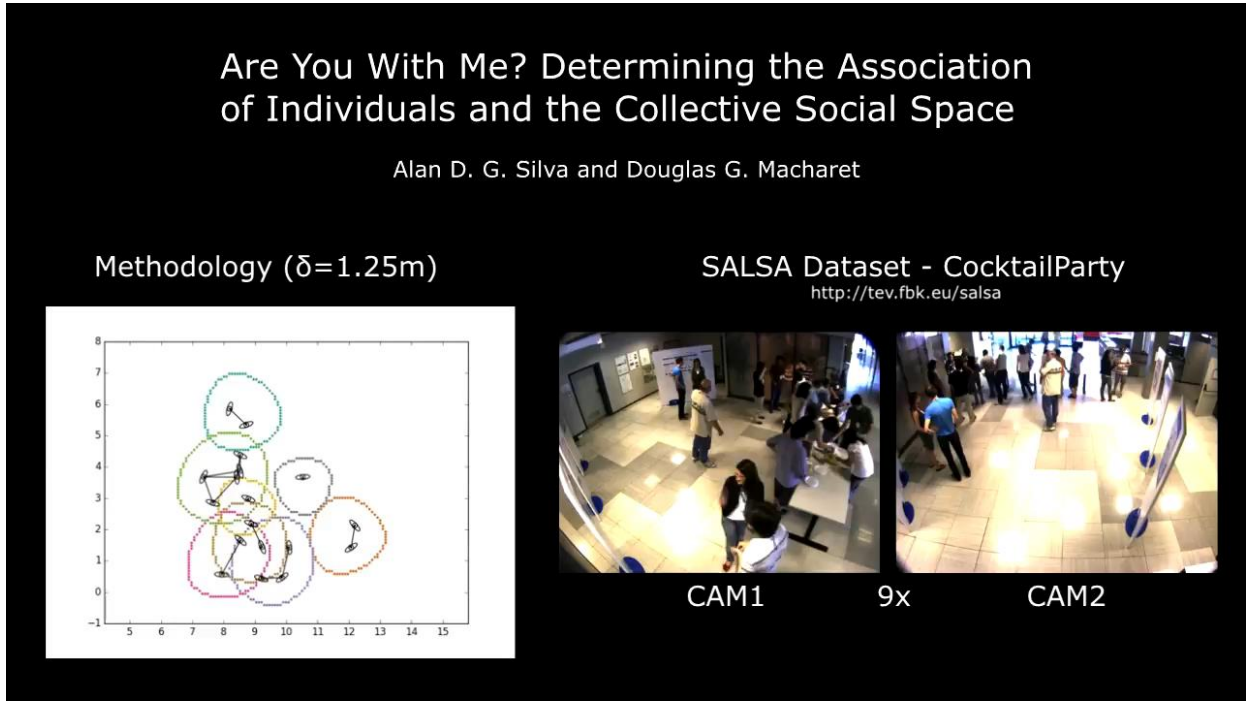


https://youtu.be/Ikp4WuwfBz0

Robótica na UFMG

VeRLab: Interação Humano-Robô



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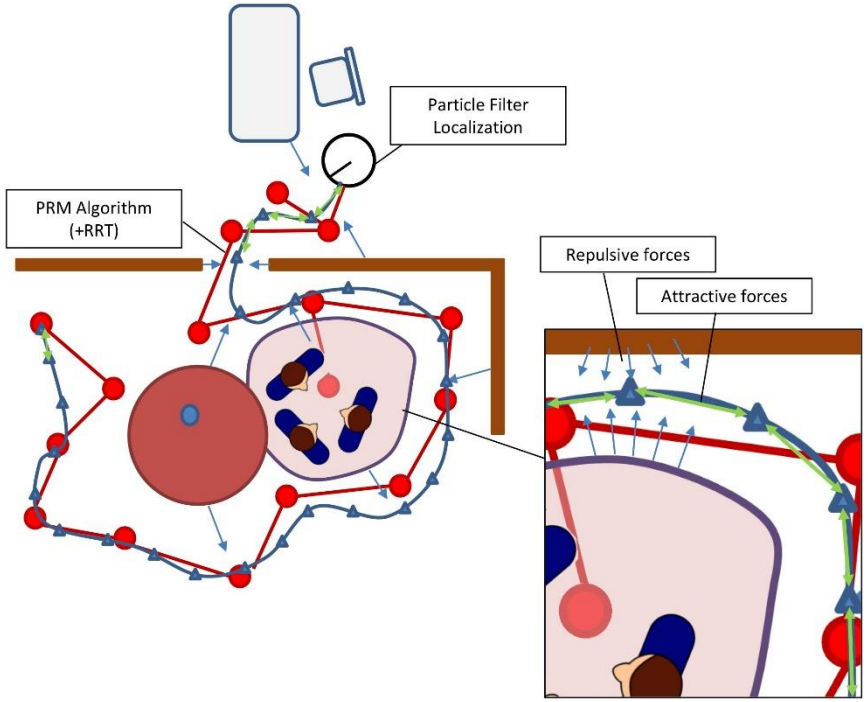

Robótica na UFMG

PDVA: Avião que Voa Sozinho (AqVS)

https://youtu.be/z_3tFA1geQE

Robótica na UFMG

PDVA: Carro Autônomo Desenvolvido na UFMG (CADU)

https://youtu.be/M4ZVRhNeKXU