Introduction to
Practical Robotics

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RSE2107A-Systems Engineering Project 1

Weston Robot

Agenda

- Administrative & Logistics
- Introduction to the Landscape of Robotics
- Introduction to LIMO Robot Hardware
- Basic Ubuntu Knowledge (YT Videos)
- Define the 13-week Robotics Challenge
- Define the LAB 1 Tasks

Administrative & Logistics - Objectives

Objectives:

- Big picture overview of robotics
- Industrial tools, workflows and practices

Prerequisites:

- Basic understanding of electronics, network and programming
- Good knowledge of CAD tools and 3D printing

Grading Policy:

- Labs (50%): 8 graded lab sessions, each worth 4-8%
- Final project (50%): demonstration (25%), presentation (15%), report (10%)

Administrative & Logistics - Policy

Class Policy:

- Regular attendance of both the lectures and lab sessions are essential and expected

Academic Honesty:

- Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation

Office Hours:

- After class, or by appointment, or post your questions in the forum provided for this purpose.

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Administrative & Logistics – Teams Behind the Course

YL. Zhang Ph.D.
15-Yr R&D/Business

EX-MathWorks Robotics System Toolbox Manager (USA), EX-Chief Scientist and Executive Deputy Director at SSL Robotics Institute (China). Bachelor/Ph.D. from NTU (Singapore), Post-doctoral from UofT (Canada).

RX. Du Ph.D. Candi.
WPI Dual Eng. Masters

Dual Engineer Master Degrees from Worcester Polytechnical Institute, EX-Core Team Member of DARPA Grand Challenge. EX-Intern at Autonomous Driving Company nuTonomy, Ph.D. Candidate from WPI.

H. Kurnia
NUS Computer Eng.

Robo Master core team member from NUS, Computer Engineering Degree from SOC in NUS, developer at NUS Advanced Robotics Center.

L.P. Loon
University Technology Malaysia

1st prize in Hack for Good 2.0 Hackathon 2019. 1st prize in UTM Grand Challenge competition 2019. Best Idea Award in ABU ROBOCON Vietnam 2018.

XP Tang
Ex-Panasonic Design Lead

Lead mechanical robotics engineer with 15+ year experiences with consumer products design and prototyping, family with CNC, 3D printing and other prototyping skills.

Wendy
SIT Yr3/Yr4 Student

Albert
NTU Yr3/Yr4 Student

Kartheegeyan
NUS Yr3/Yr4 Student

Matthew
NUS RoboMaster Team Leader

Prof. Liew
Mr. Vishal Vaswani
Mr. Kenichi Kato

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Bridge the Gaps

Mitigate the Pain Points

Reality

- USD 30K +
- Frequently Down
- Picky about Places
- Single Task

GAP

Expectations of Robots

- Expected ROI
- Less Intervention
- Safe
- Multitasking

Challenges for Deploying Robots

Every Aspect of Our Life

*photo from Boston Dynamics

CAPEX:
USD 70k+*

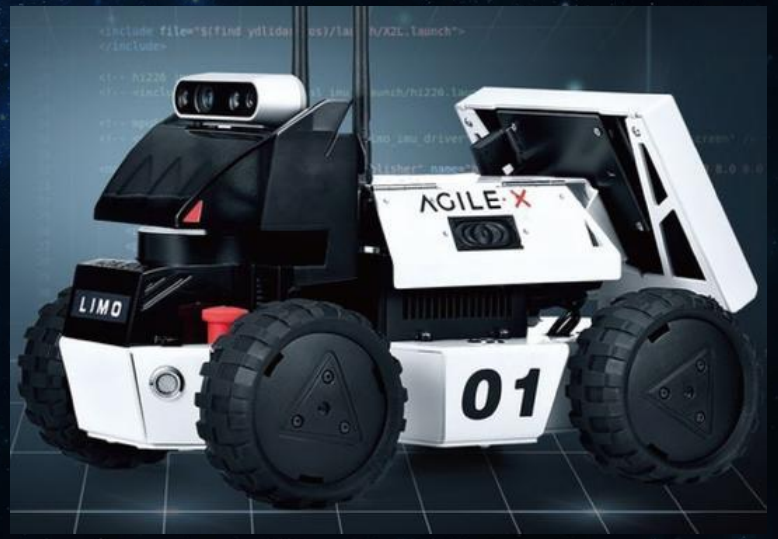
OPEX:
~??

Right Picture: Men ride e-bicycles inside the 60 meters-below ground East-West tunnel, part of SP Group's cable tunnel project, seen on 19 Dec, 2017. Photo: Jason QuahRead more at https://www.todayonline.com/singapore/deepest-tunnels-spore-start-carrying-electricity-end-2018

Technicall Challenges

Whiteboard: Difference and Commonality - System

Multi-Disciplinary Work



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Whiteboard: Difference and Commonality - Application

Multi-Disciplinary Work

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Building Blocks of Robots

Multi-Disciplinary Work

Robotics Components

1. Mechanisms	2. Actuators	3. Sensors	4. Controllers	5. Reducers	6. Power	7. Vision	8. Software	9. Processors	10. Material
Design	AC/DC Motor	2D/3D Lidar	Model & Analysis	RV	Battery/BMS	IP/GMSL Camera	ROS/MBD	X86/ARM	Friction
Simulation	Smart Actuator	Ultrasonic/ToF	Sys. ID&PID Tune	Harmonic Drive	Intel. Regulator	RGBD/VSLAM	Simulator	GPU/FPGA	Rigid/Soft mat.
Prototyping	Hub Motor	Touch/Force	MIL/SIL/PIL/HIL	Worm Drive	Auto Charging	Video Streaming	CI/CD/Git	RTOS	Carbon Fiber
Production	Micro/Nano Dri.	Pressure/Temp.	Energy Opt.	Chain Drive	Solar Power	Video Analytics	Docker/Con.	Data Center	Micro/Nano

Robotics Systems

Tools & Machines	Robot Arms	Legged Robots	Wheeled Robots	Special Robots
CNC Machining	Industry Robot Arm	Robot Dog	AGV/AMR	UAV/Drone
Inspection & Measure.	Collaboration Arm	Humanoid Robot	Tracked	USV
Injection Molding	Pick & Place Cell	Human Robot Inter.	Scooter	Integrated System
...	...	...	...	...

\+

AI + Connectivity + Navigation

Scene Understanding
Cloud & Edge Training and Deployment
Lift/Elevator/Door Integration
SLAM/Navigation
4G/5G/WIFI/UWB/Bluetooth/RTK/...
IoT/Blockchain...

Robotics Applications

Smart Factory	Smart City	Smart Logistics	Smart Agriculture/Urban Farming	Smart Home
Industry 4.0	Autonomous Taxi	Autonomous pick-and-place	From Farm to Fork	Cleaning Robot
Customer to Factory	Patrolling Robot	Smart inventory projection	Precision Planting/Caring	Accompanying Robot.
Inspection ALL	Smart Restaurant & Hospital	Smart warehouse	Pick and Place	Education Robot
Trusted Supply Chain...	Smart Construction	Smart cargo	Auto Recycling	Personal Assistant Robot

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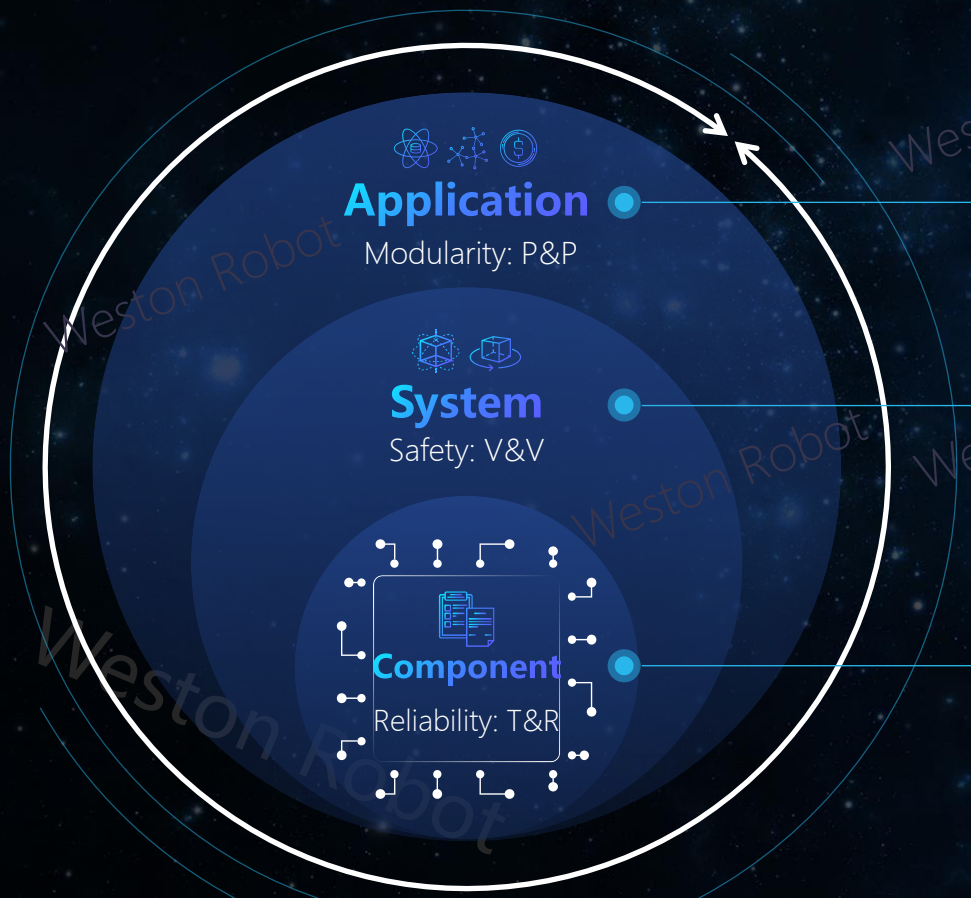
Robotics: More than Just Building Blocks

Can Guarantee 99.x% Up Time?



WR Frontend Smart Field

PPL Safe | Object Opt. | Field Mining

WR Backend Intelligent Module

5G Conn. | Remo. Contrl. | All Recog. | Task Sched.

Application – P&P

Mobi.
- Localization
- Go Home
- Auto + Human
- HW Isolation

Expa.
- Payload & PW
- Quick Swap
- Shared Modul.
- OTA + ROS

Safety
- Sys. Modelling
- Virtual Reality
- Test Harness
- Certi. + V&V

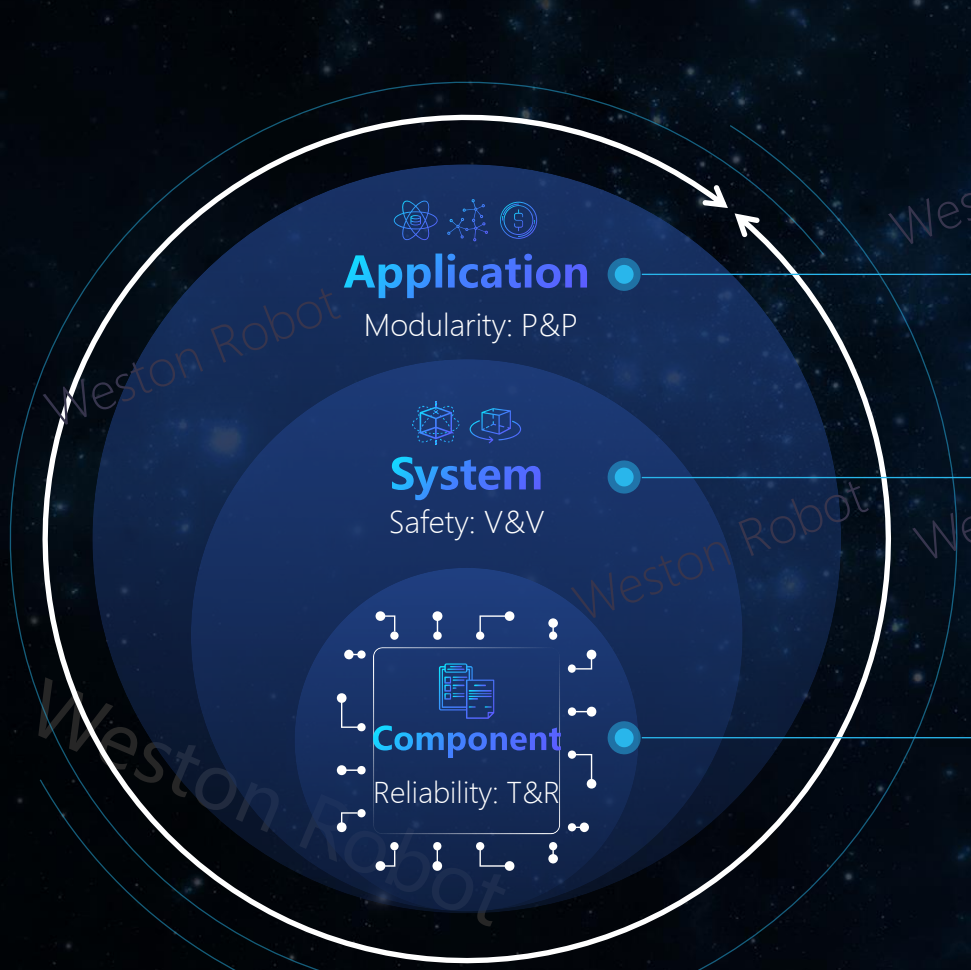
System – V&V

Model | **Control** | **T&R**

Component – T&R

Introduction to Practical Robotics

Can Guarantee 99.x% Up Time?



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Application – P&P

Mobi.	Expa.	Safety
Localization	Payload & PW	Sys. Modelling
Go Home	Quick Swap	Virtual Reality
Auto + Human	Shared Modul.	Test Harness
HW Isolation	OTA + ROS	Certi. + V&V

System – V&V

Model | Control | T&R

Component – T&R

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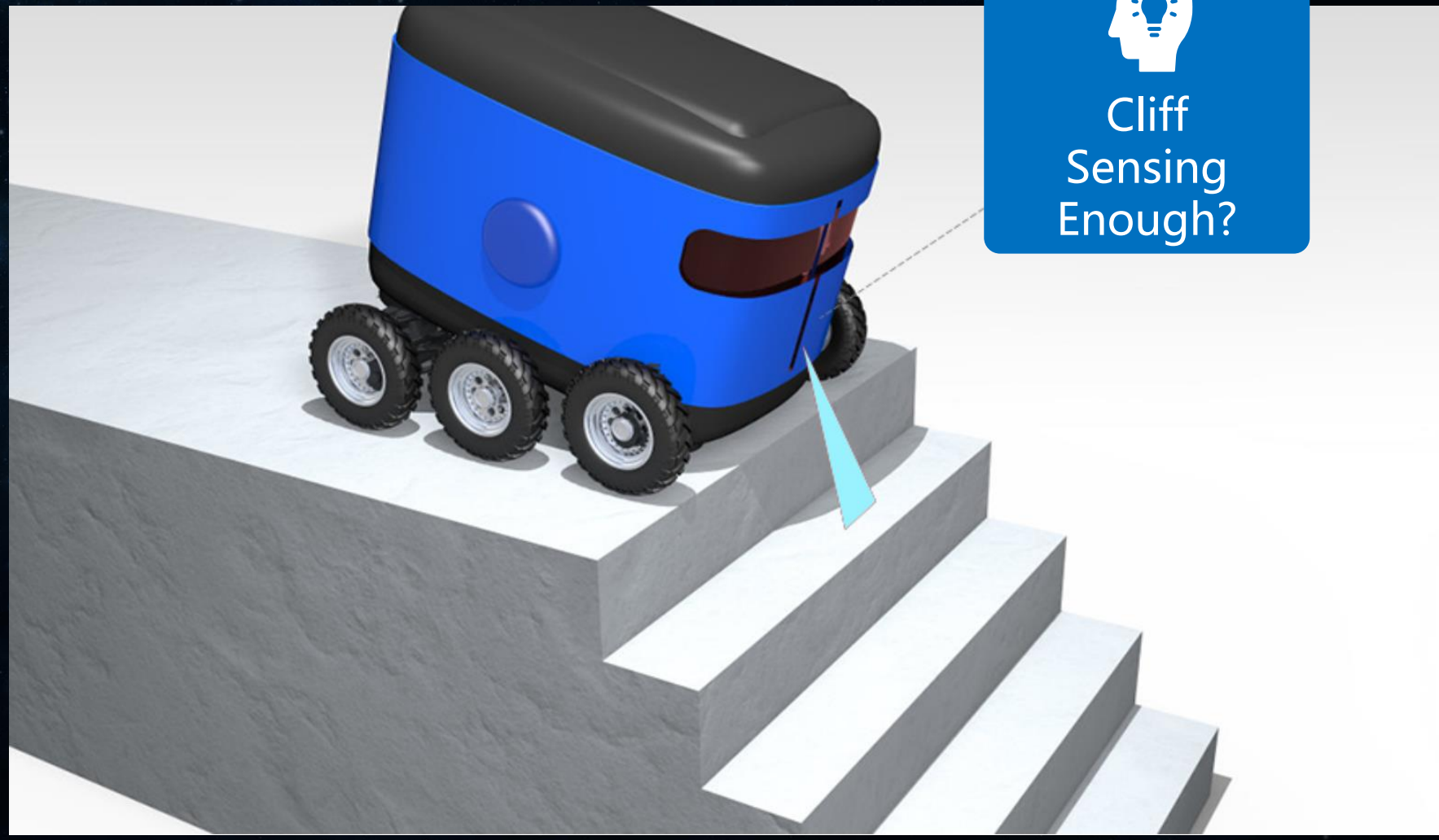
Safety Uncompromised?

Human and Property Friendly



Cliff Sensing Enough?

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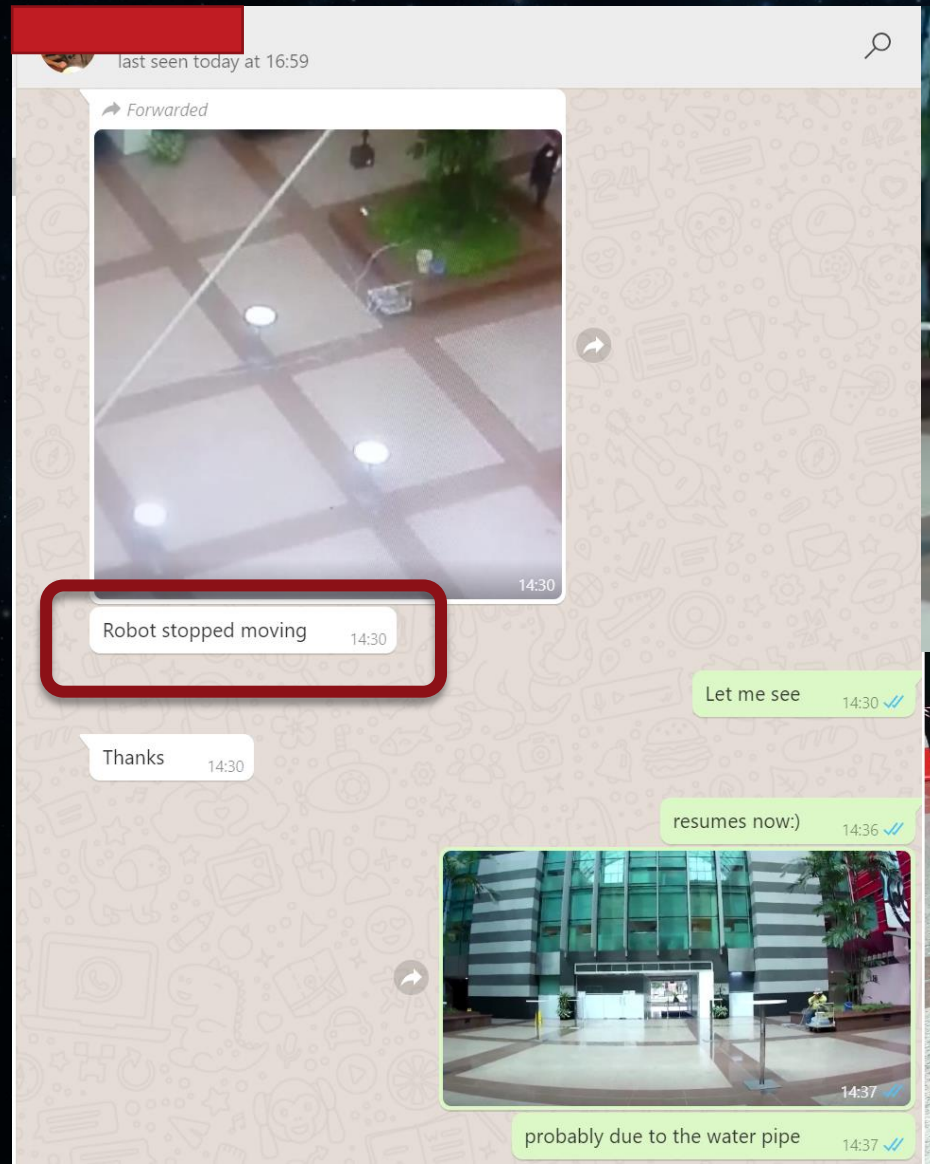
Truly Autonomous?

Less Human Interventions Preferred



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Smart Enough?

Liability and Affordability

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Infrastructure Ready?

Liability and Affordability

COVID-19 Related Robots

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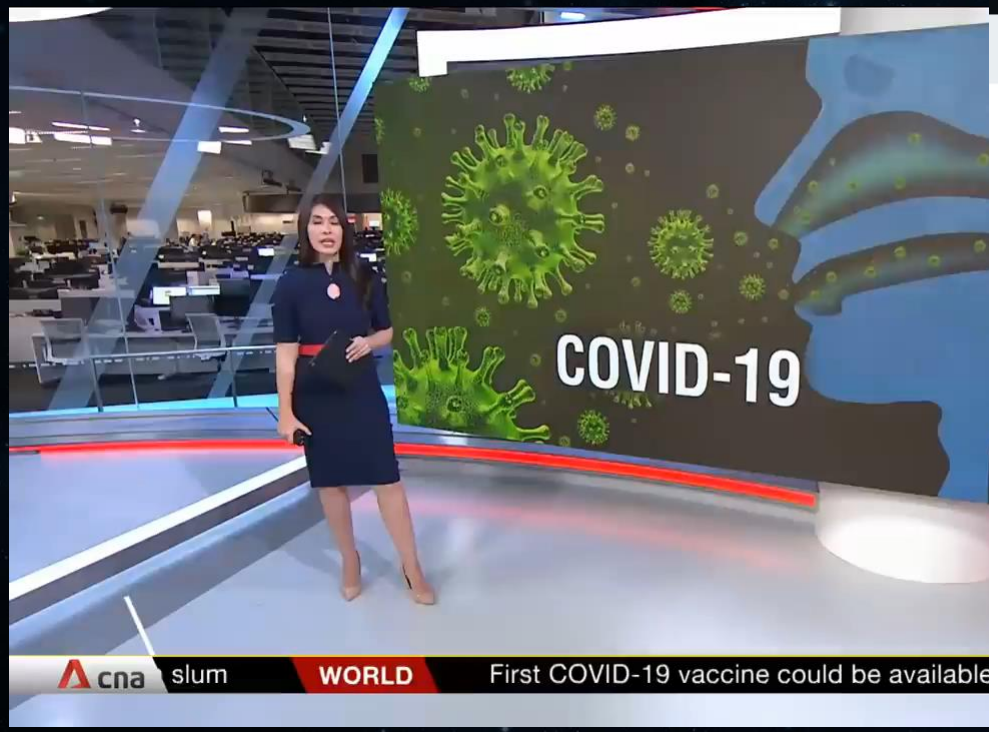
10-Day Innovation

Developed the World First COVID-19 Robot



World 1st COVID-19 Disinfection Robot Developed in 10 Days

zdnet.com/article/a-1

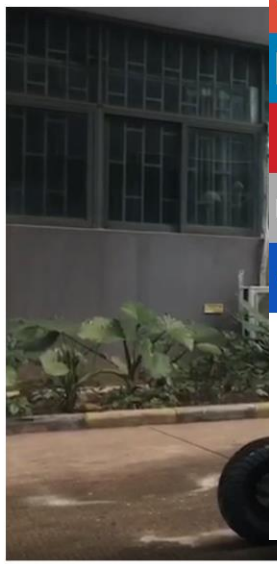
ZDNet

PART OF A ZDNET SPECIAL FE

A 10-day robots

The pandemic has b

Shares



fmme

SECTORS

Ten days t

The *New York Tin* first reported cas

This pandemic hi developer and su leading the way f

"Back to January, coming up with t companies follov at Weston Robot, Singapore.

A 10-Day Dash to Build Robots That Fight COVID-19

Mobile Robots Help Disinfect High-Touch Surfaces

At just over three feet (.98 m) tall, the four-wheeled robot may not look like much as it rolls through the office parks of urban Singapore—but don't let that fool you. Equipped with commercial-grade disinfectant and a double-barreled spray gun, the small robot from Weston Robot is diligently disinfecting any high-touch surface in its path. Whether it is being remotely controlled by personnel offsite or autonomously cruising empty hotel rooms with an infection-zapping UV light, this robot is diligently going where humans no longer should.

> Weston Robot designed three new disinfecting and temperature-monitoring robot prototypes. Each took just 10 days.

The disinfecting robot designed by Weston Robot and AgileX. Image credit: AgileX

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COVID-19 Related RaaS Cases

Mask Detection – Social Distance Checking

Mask Detection and Social Distance Robot
Ministry of Communication and Information

Mask Detection and Social Distance Robot
Marina South Pier

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COVID-19 Related RaaS Cases

Mask Detection – Social Distance Checking

Mask Detection and Social Distance Robot
National University of Singapore

Mask Detection and Social Distance Robot
IMDA

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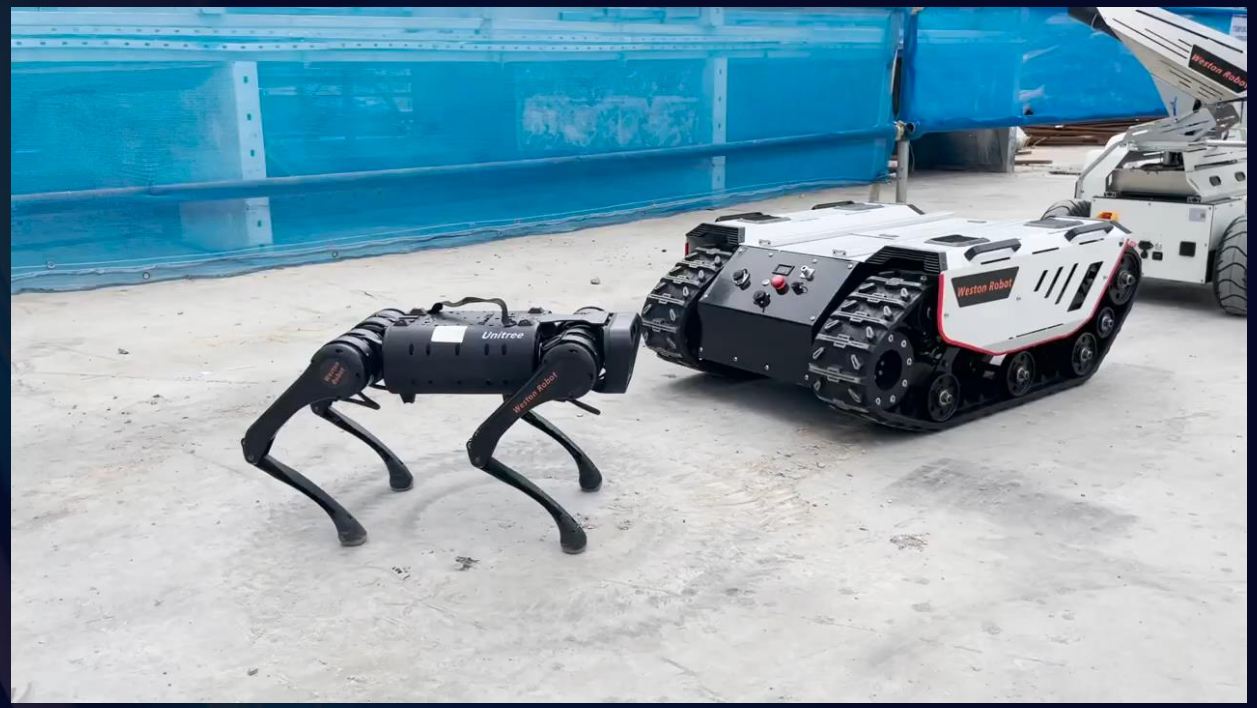
Construction RaaS Deployment

Material Handling and Disinfection



Material Handing
Singapore Construction Sites

Disinfection
Singapore Construction Sites

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Park Disinfection

Combat COVID-19

Outdoor Disinfection Robot

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Table/Toilet Cleaning

Combat COVID-19

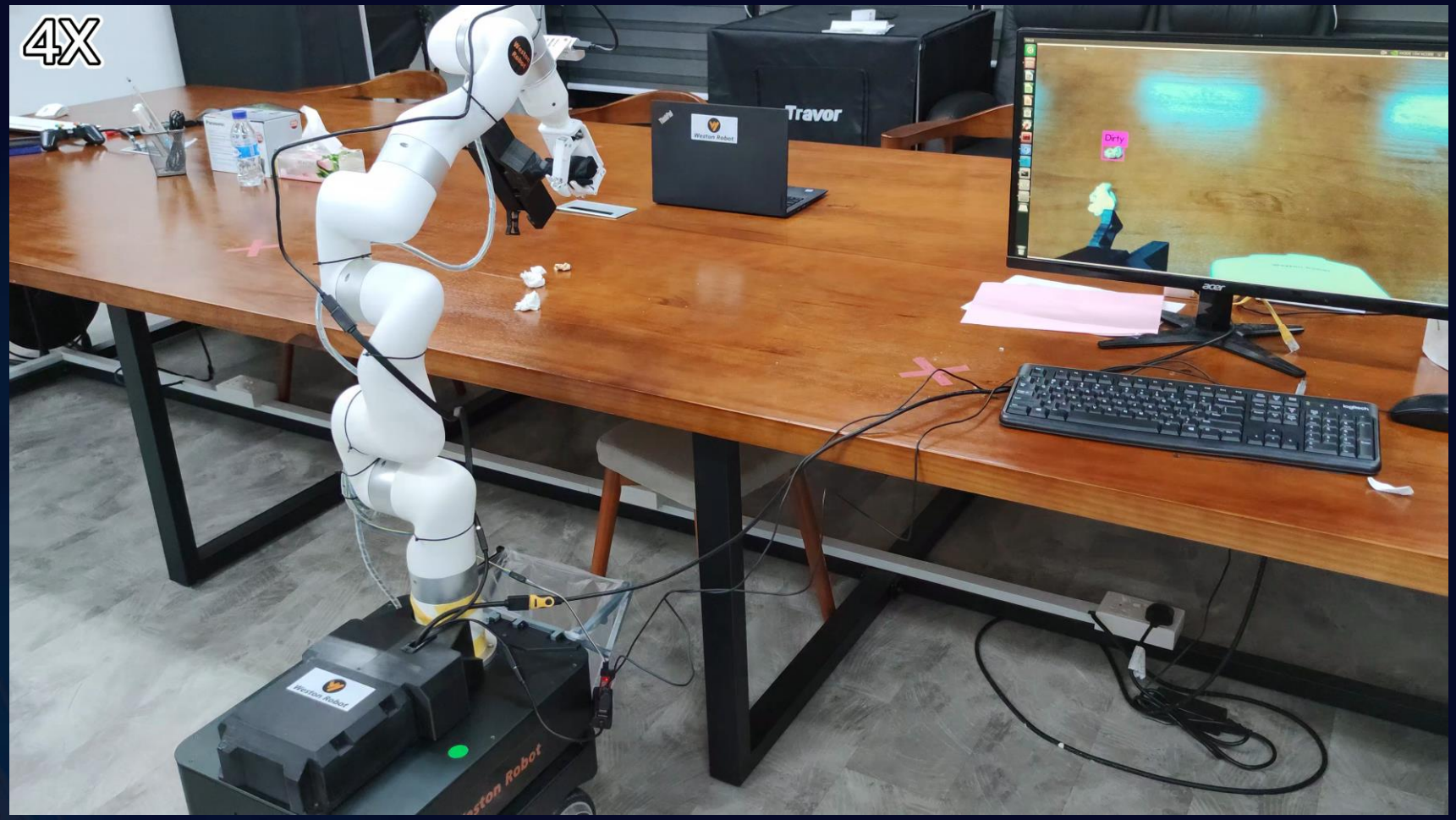

Table Disinfection Robot

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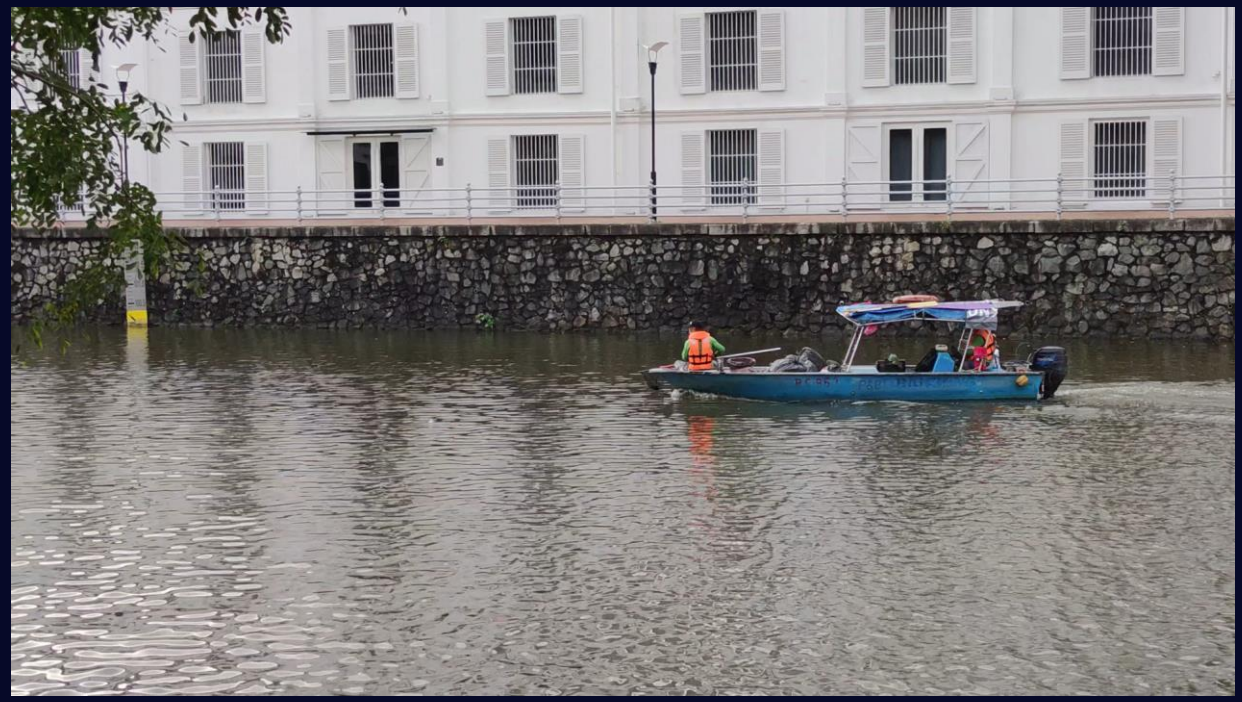
Garbage Collection

Aim for Smarter, Cleaner and More Sustainable Singapore

Garbage Collection
At Marina Bay Floating Platform
Recorded by Weston Robot in 2018



Garbage Collection
At Singapore River
Recorded by Weston Robot in 2022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Carbon-Zero Mowing

Mowing at National Parks

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Carbon-Zero Mowing

Mowing at National Parks

Digital Twin Integration for FM

Building and Construction FM

Guest Reception

Robot Follow Me

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Ubuntu and ROS (LAB)

Quick Introduction

Ubuntu Videos:

- What is Linux: https://youtu.be/PwugmcN1hf8
- History: https://youtu.be/SDMQxLblarE
- Quick Guide: https://youtu.be/lmeDvSgN6zY
- Linux File System/Structure: https://youtu.be/HbgzrKJvDRw

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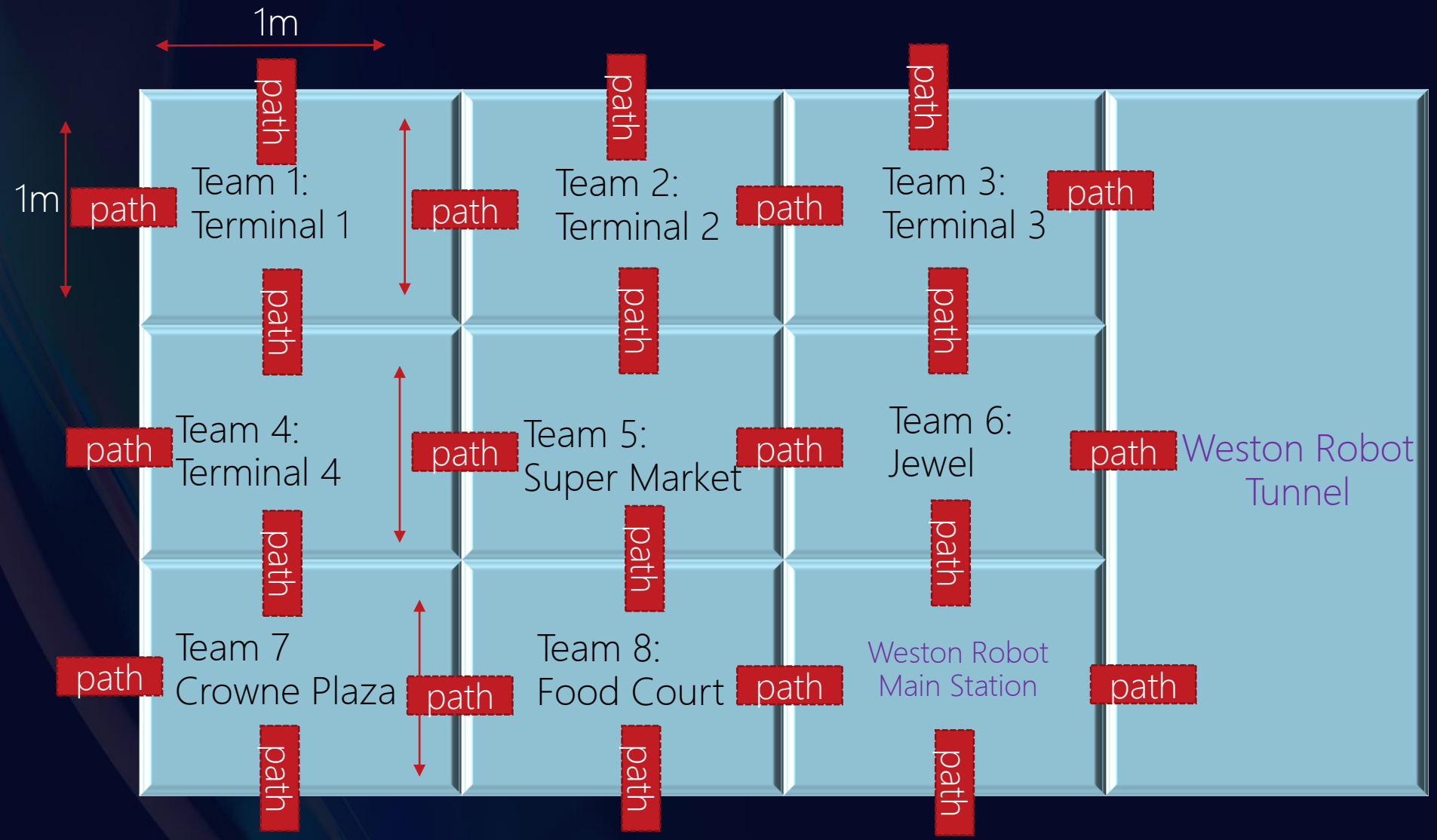
13-week Robotics Challenges: Navigate through "Changi Airport"

Quick Introduction



Each Team: One LIMO

13-week Robotics Challenges: Navigate through "Changi Airport"

- Form a team of 5 (different expertise)
- Design and make the 1m*1m maze (budget $$) (week 1 – 7)
- Complete the 8 lab sessions (pre-lab, lab and report)
- Compete in the final challenges
  - Navigation challenge
  - Line tracking challenge