ASSOCIATION OF ENGINEERS, ARCHITECTS AND GRADUATES IN TECHNOLOGICAL SCIENCES IN ISRAEL

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Intelligent Driving in a Special Environment
特殊环境中的智能驾驶

The Hebrew University Online Program

Dr. Nir Karasikov

8-2022

主讲人：希伯来大学线上项目Nir Karasikov博士

NANOMOTION
A Johnson Electric Company

JOHNSON ELECTRIC
innovating motion

multi moby

Content 课程大纲

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- Sensors types, capabilities and limitation
- Sensing strategies
- Computation approaches
- Passive and active sensing
- Examples
  - Warehouse
  - Last mile
  - Bikes

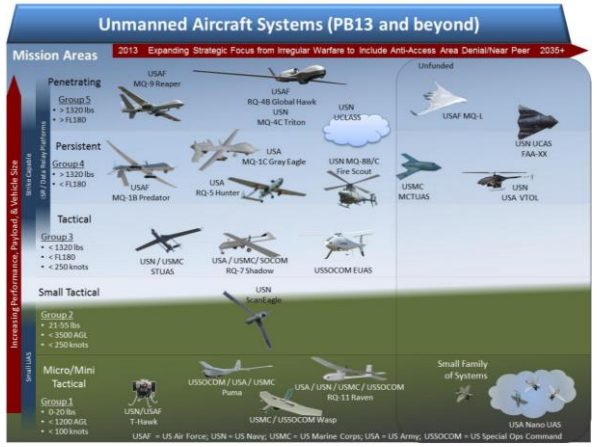
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Introduction 简介

- Autonomous Vehicles is a mega trend
- Sensors are the facilitators for AV –
  - Navigation
    - GPS
    - Optical flow
  - Obstacle avoidance
  - Job to be done
    - Inspection
    - Measurements
- LiDAR is getting a lot of attention – good for long range
- The presentation analyses LiDAR and Imaging sensors, which are the base for the missions above

Types of Autonomous Vehicles
不同类型的自动驾驶汽车

NASS
Dr. Nir Karasikov
Technology and Business Consultancy



AGV

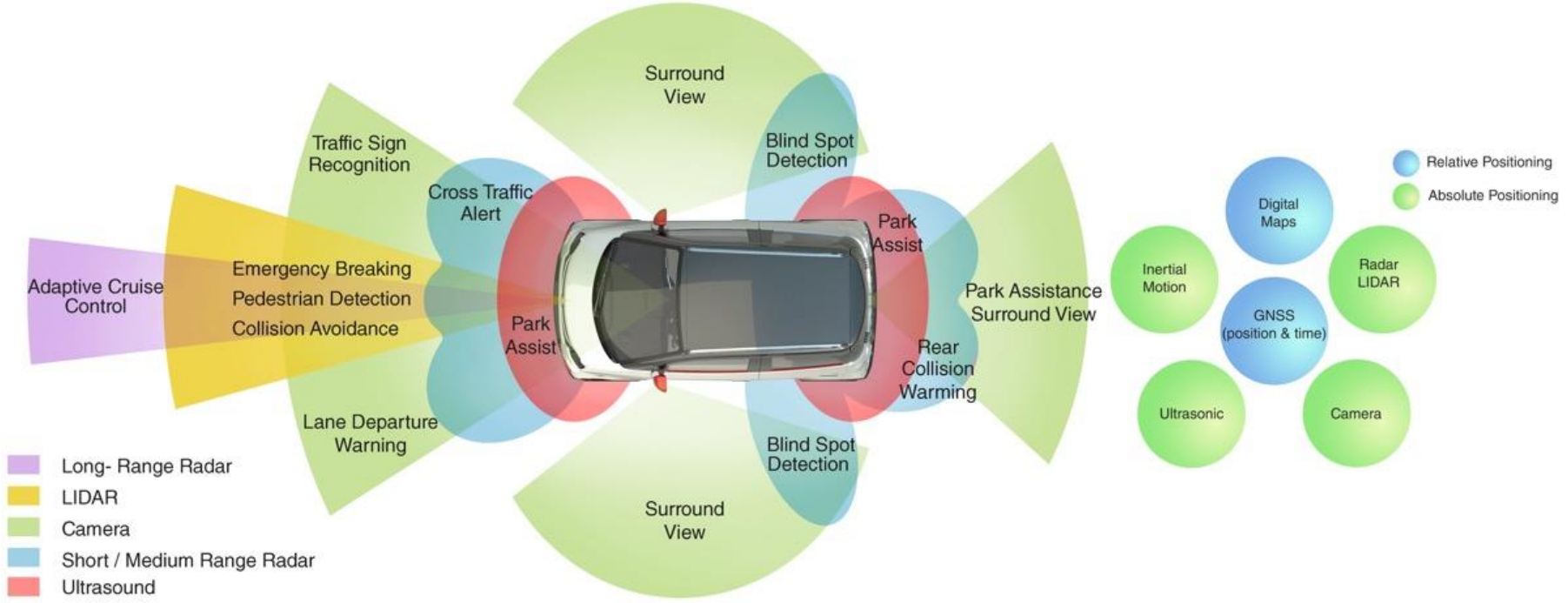
AV

- Different challenges
- AV is the most complex

Present Common AV Approach
当下常见的自动驾驶汽车相关技术

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Typical sensor suite utilized in a level 4 AV: scaring level of complexity



- Lidars, Radars, Inertial Motion units IMUs, Ultrasonic US, are all relative.
- Cameras combined with maps can help Navigation in mapped areas at Level 3.
- Level 4 autonomy cannot be achieved without GNSS.

Overview of the Role of Edge AI in Automotive Industry
边缘人工智能在汽车产业中的作用简介

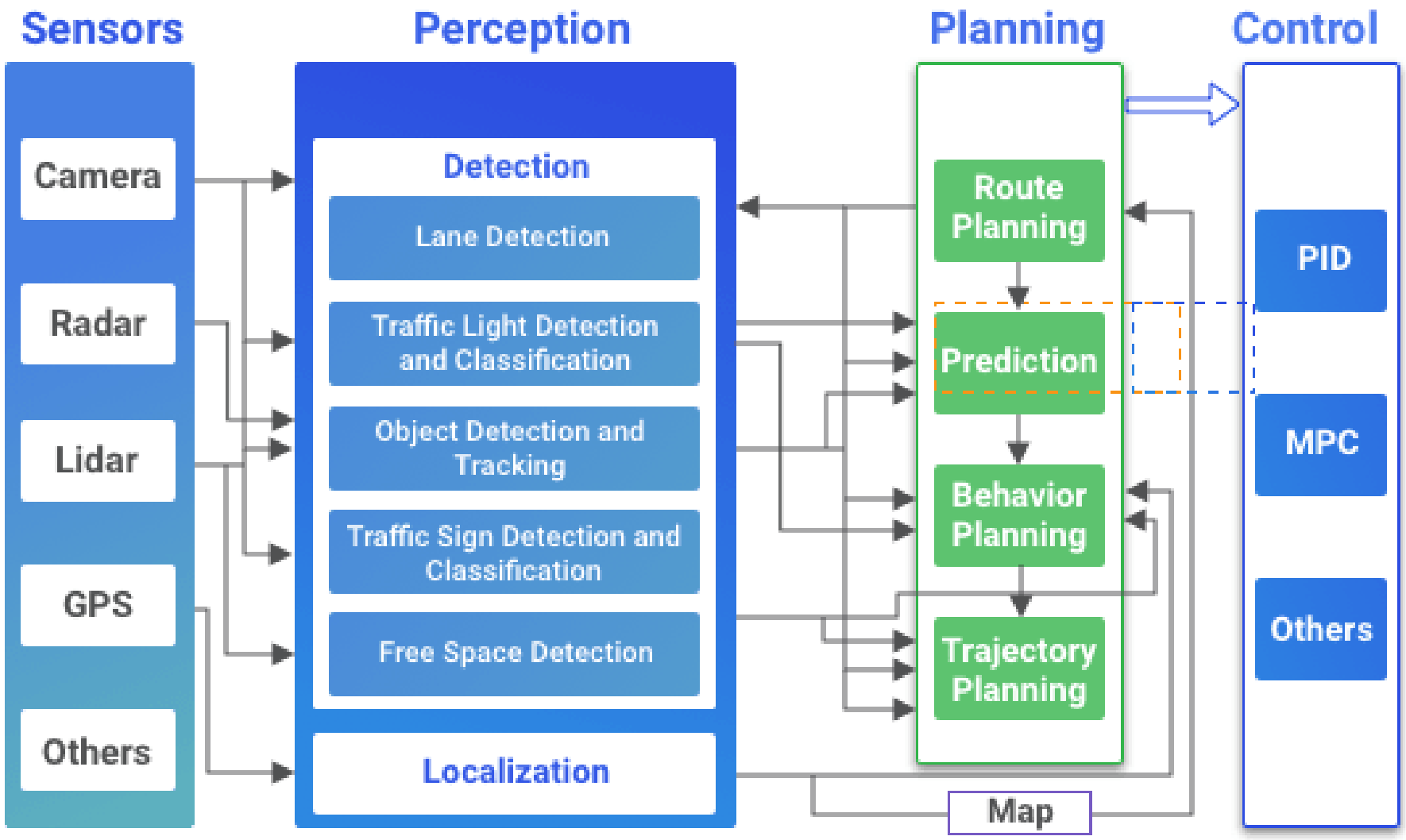
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- http://www.akira.ai/blog/role-of-edge-ai-in-automotive-industry/?hs_amp=true

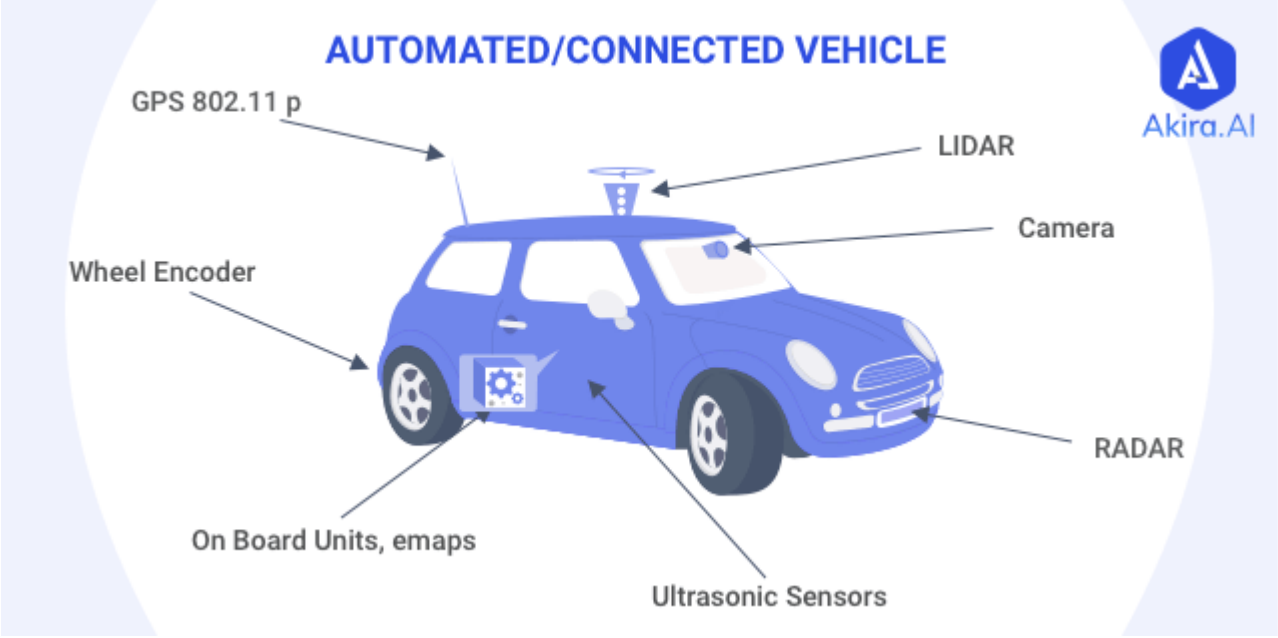
What is the Architecture of Edge AI in Automotive?
边缘人工智能在汽车领域的架构是怎样的?

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- At a high-level architecture, automated vehicles have four major components: Sensors, Perception, Planning, and Control
- All the components perform together to grasp the environment around the automobiles, plan destination routes, predict vehicles and pedestrians' behavior, and finally move according to instructions like drive smoothly and safely


Sensors
Perception
Planning
Control
Camera
Radar
Lidar
GPS
Others
Detection
Lane Detection
Traffic Light Detection and Classification
Object Detection and Tracking
Traffic Sign Detection and Classification
Free Space Detection
Localization
Route Planning
Prediction
Behavior Planning
Trajectory Planning
Map
PID
MPC
Others

The technology used in Autonomous Vehicles
自动驾驶汽车中用到的技术项目



Sensors 传感器系统

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- **Cameras**

Vis, SWIR, MIR, Gating

- **Radar**

No doubt radar has the lowest resolution, still can see through adverse weather conditions, unlike LiDar, which is mainly light-based. It can propagate through rain or snow like things

- **LiDAR**

LiDar is a light-based sensor, and it is placed on top of self-driving cars spinning around. It helps in generating a highly-detailed 3D map of its surrounding as feedback through shooting out the light

LiDAR has a higher resolution than RADAR being light-based it has limitations in low-visibility weather

- **Other Sensors**

Sensors like Ultrasonic Sensors, inertial sensors, and GPS 802. IP are also used for self-driving cars to fully image what is occurring around them and what the car is doing

Perception 感知系统

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- The perception subsystem mainly contains software components that grab all sensor data and merge them into meaningful, structured information through sensor fusion and understand the Autonomous vehicle's environment

- Perception is broadly divided into parts, i.e., Localization and Detection
  - Localization: This system gets data from GPS (Global Positioning System) and maps to detect vehicles' precise location. It helps form the basis for other functions that will be used later
  - Detection: This system gets data from other sensors like radar, LiDar, and other sensors to perform different functions like lane detection, traffic light detection and classification, object detection and tracking, free space detection

Planning 规划系统

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- Input for the planning subsystem is collected from the perception subsystem and used for long-range planning (e.g., road planning) and short-range planning (such as which turns to take). There are four prominent planning positions in place
- **Route Planning**
  - The car will follow between two points on the map for the path, e.g., the highways and the roads to take, the route designer maps out high-level, rough plans
- In most vehicles, this is like the navigation system. The route planner mainly takes the information from the map and the GPS

Prediction 预测系统

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- The forecast aspect forecasts other cars' actions, barriers, pedestrians on the road in the autonomous vehicle's vicinity
- It uses probabilistic simulations to make informed predictions about their next positions and possible trajectories
- All this is achieved to navigate the **Autonomous vehicle** around them safely
- The prediction aspect involves input from components such as a lane detector, a traffic light and a signal detector/classifier, and an object detector/tracker

Behavior Planning
驾驶行为规划系统

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- The behavior planner then uses data from the predictor and the fusion sensor to schedule its behavior, such as staying in the current lane, shifting lanes (right/left), or braking at the traffic light, or accelerating as required
- The behavior designer incorporates input from components such as a lane tracker, a traffic light and a signal detector/classifier, a free space detector, and a localize

Trajectory Planning 轨迹规划系统

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- The trajectory planner takes the immediately planned behavior of the behavior planner and generates multiple trajectories while keeping track of user comfort (e.g., smooth acceleration/deceleration), road rules (e.g., speed limits, etc.), vehicle dynamics (e.g., body weight, load, etc.) and determines the exact trajectory to be taken
- This direction is transferred to the control subsystem to be executed as a series of commands
- The trajectory planner gathers up information from the lane detector, object detector/tracker, free space detector, action planner, and also feeds information back to the behavior planner
- Continuing the Waymo case, we see how the Forecast and Preparation components help Waymo address the following two questions: What will happen next? And What Should I Do?

Control 控制系统

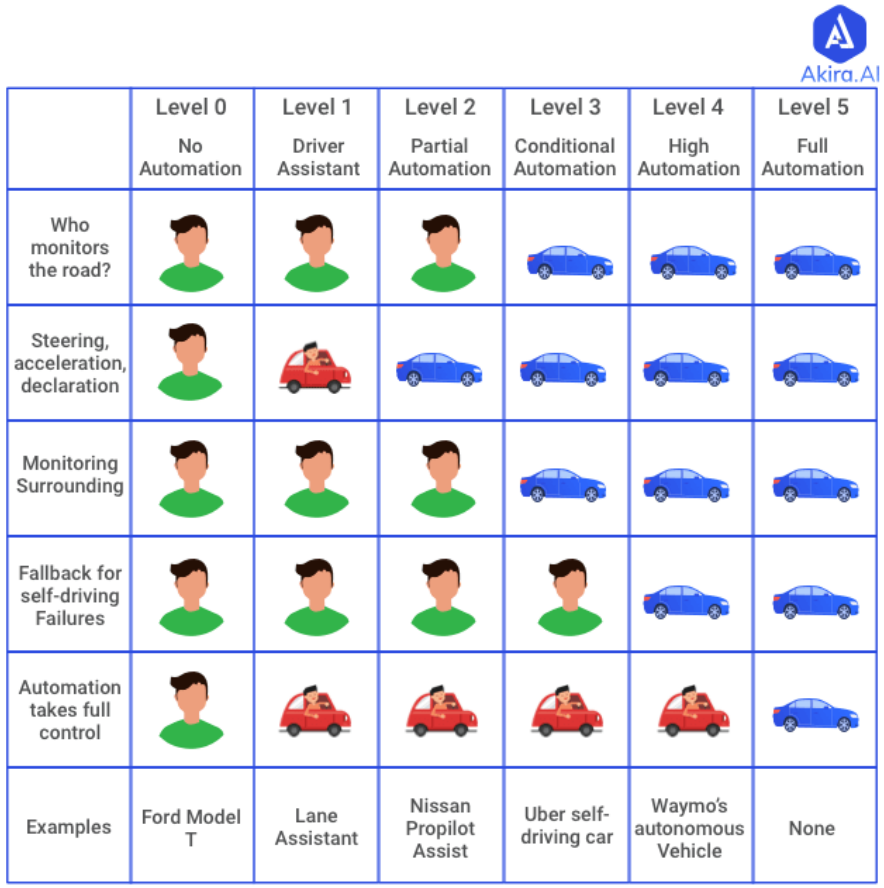
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- The control subsystem is the final system that takes instructions from the planner and performs them through acceleration/deceleration (i.e., throttle), accelerating or steering
- It guarantees that the vehicle follows the trajectory it receives from the planning subsystem
- The control subsystem usually uses well-known controllers such as PID controllers, Model Predictive controllers, or other controllers
- The controllers submit information for throttle, acceleration, and steering actuators to move the vehicle
- This completes the knowledge flow from sensors to actuators, replicated continuously when the car is at the Autonomous vehicle level

Levels of Autonomy
不同自主程度的自动驾驶系统

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- **Level 0:** In level 0, a car is completely handled by the drives all the times
- **Level 1:** In level 1, every vehicle's controls are automated, such as automatic braking and electronic stability control.
- **Level 2:** In level 2, at least two significant controls are automated, such as steering acceleration and deceleration.
- **Level 3:** In level 3, around 75% of controls are automated. This car monitors road, surrounding, and acceleration-deceleration of steering.
- **Level 4:** In this level, the driver almost dependent on the car for all functionalities for security, and the driver does not need to control the vehicle at any time.
- **Level 5:** In Level 5, We have humans as passengers only, and all functionalities are handled by card only.



What are the Applications Of Edge AI in Autom Industry?
边缘人工智能在汽车领域都有哪些应用?

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

There are various Edge AI applications in the Automotive Industry. A few of them are defined below

- **Sensor Data**
  - The sensor technology used for self-driving cars is a camera, and it captures every angle required to drive a car.
- **Electric Vehicles**
  - Edge AI in electric vehicles or driverless cars is immediately processed within the same device, and action is performed within milliseconds.
- **Smart Traffic Management**
  - Like in the real-life scenario, we have traffic lights, especially for four sides roads, which are heavily used most of the time, and vehicles need to wait for some time. This vehicle estimates the intersection with other vehicles and pedestrians and helps from a collision.
- **Vehicle Security**
  - Applying Edge AI in automobiles includes a significant amount of technology in them. The hardware like a sensor, camera, radar, lidar, and other sensors inside these cars has stayed fairly consistent. That provides the high level of security to vehicles.
- **Predictive**
  - Edge AI continuously monitors various parameters like breaking tire inflating, acceleration, and many more. Analytical models help predict any component's failure and alert the owner.

Conclusion 结论

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- AI is one of the technology sector's fundamental engines, with a growing level of importance in all scenarios
- Explainable Artificial intelligence in the automotive industry is more than the concept of self-driving cars
  - It can connect us and keep us safe while driving ourselves
- All of this means that there is a lot of activity in these areas. The estimated value of AI in manufacturing and cloud services by 2024 is $ 10 billion

Sensors
传感器

LiDAR Types 激光雷达的类型

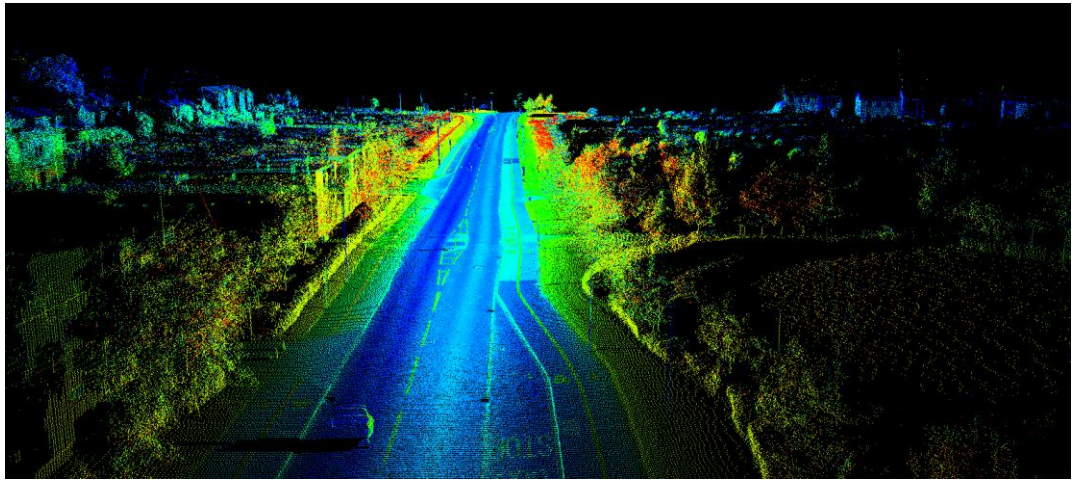
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

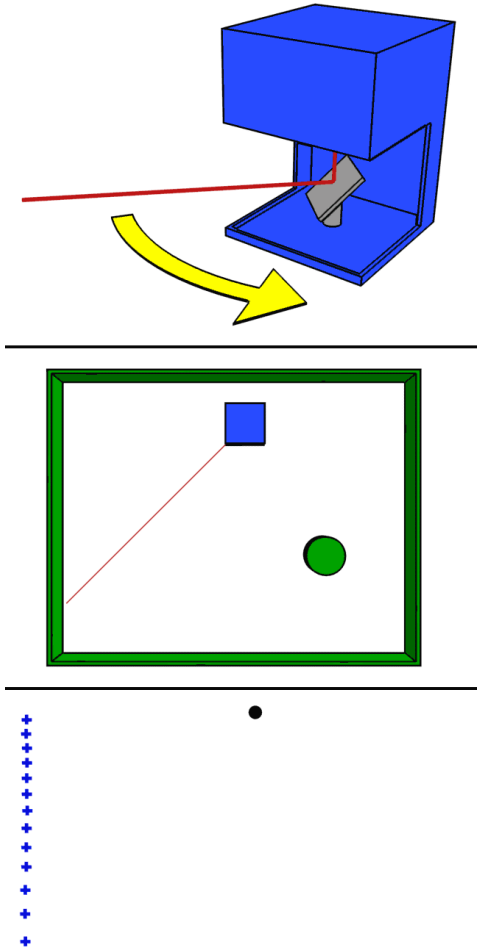
- Flash LiDAR uses a wide-angle-emitting source and wide-angle optics (a fisheye lens, for example) to focus backscattered light acquired during a single emission onto a matrix detector to obtain all the time-of-flight (TOF) data needed to model the area surrounding a vehicle
- Scanning LiDAR addresses the 3D environment line by line; light is sequentially emitted in each direction and the corresponding echoes are detected one by one by the detector
- AV uses more the scanning type due to wide FOV and lower power

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Mode of Operation 操作模式

- Scanning
- Time of Flight
- 3D point cloud – Challenge in reconstruction
- AI recognition
- Easier to train as the information is 3D

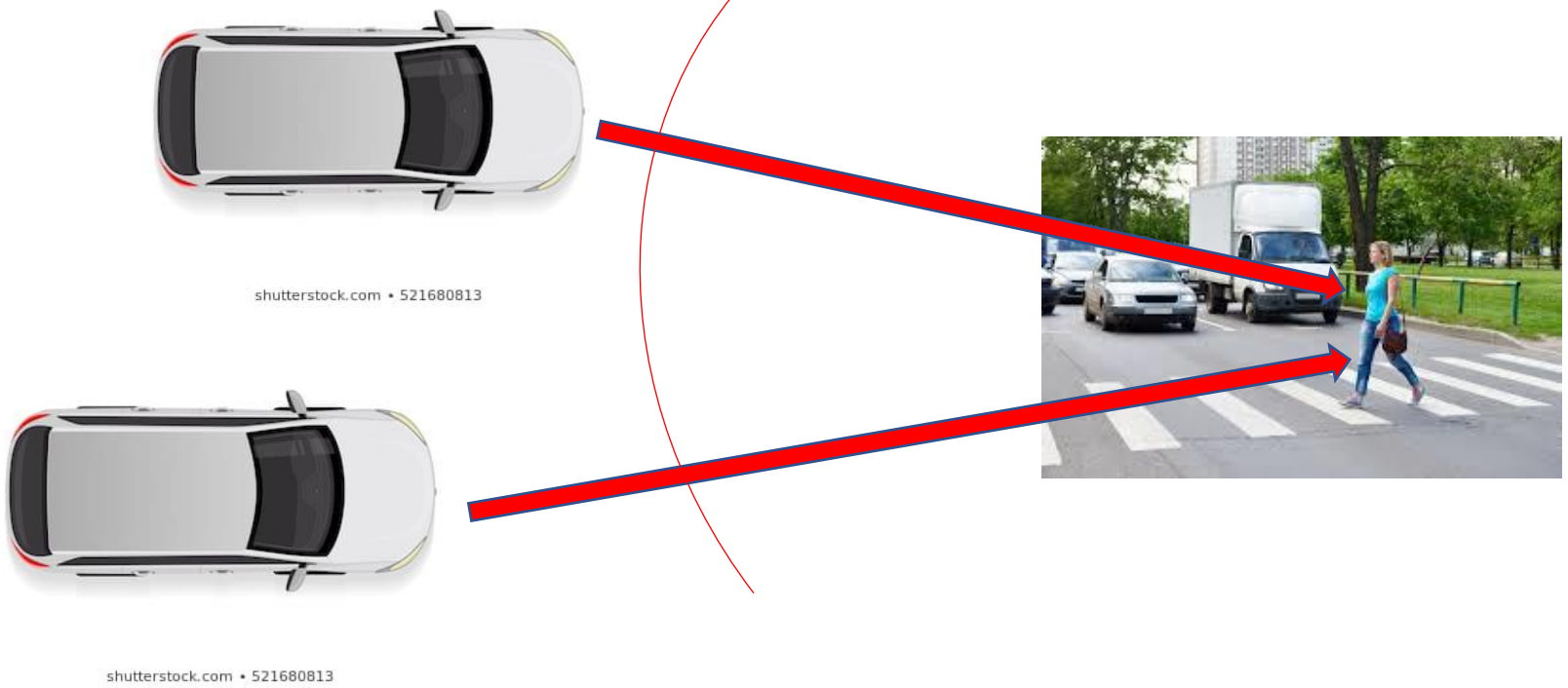




Crosstalk from Other LiDARs?
会不会受到来自其他激光雷达的串扰?

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- Lambertian scattering
- Both Lidars will receive an equivalent signal from the adjacent LiDAR. Each LiDAR will receive two ambiguous signals. Real and Ghost



NASS

Dr. Nir Karasikov

Technology and Business Consultancy

An Alternative PASSIVE Approach

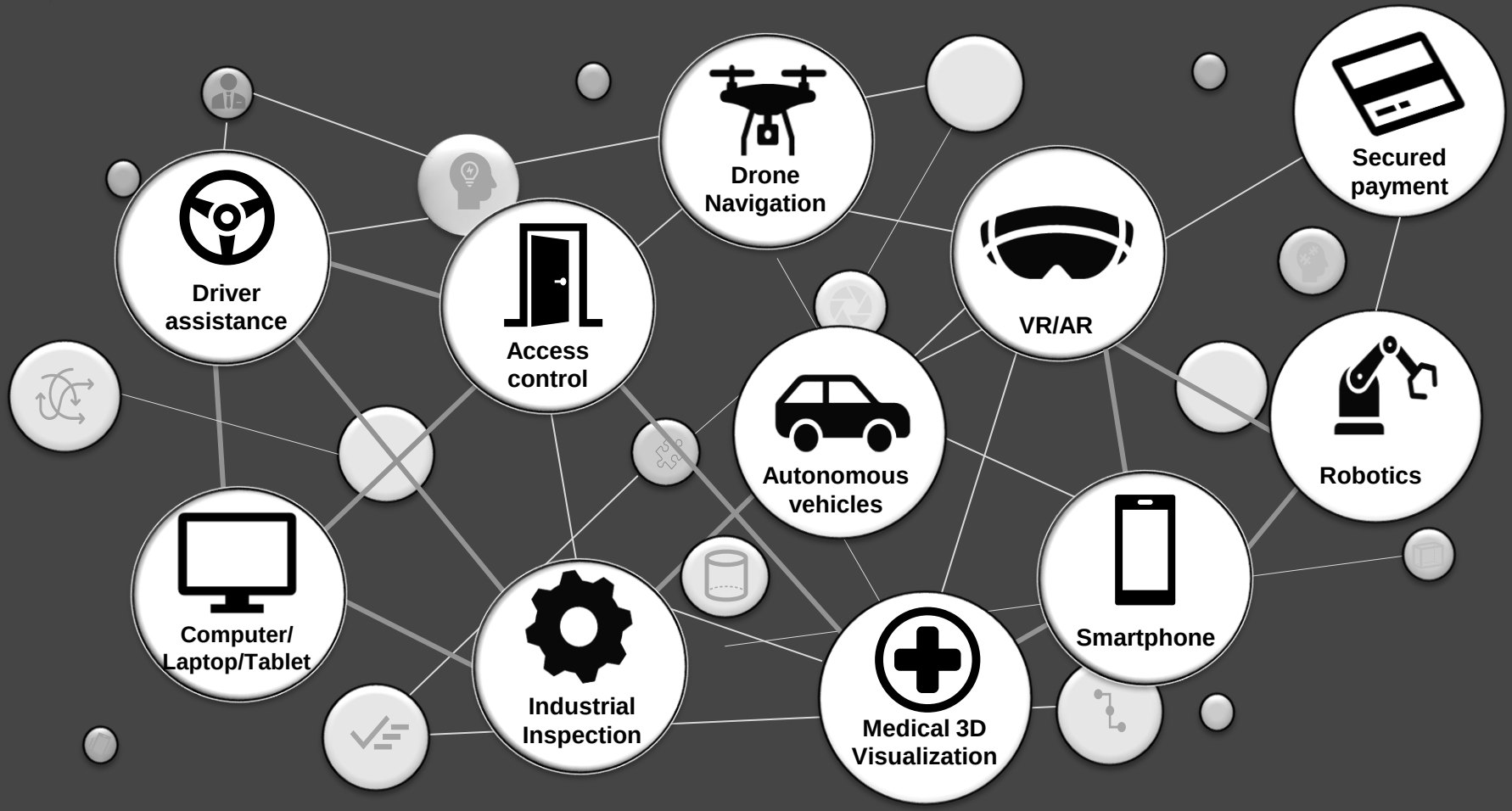
MultiVu®

Simplifying 3D Imaging for AGV

www.multivutech.com

替代方法一——MultiVu公司的自动导引运输车简化三维成像技术

3D Imaging Applications
三维成像的应用



MultiVu®

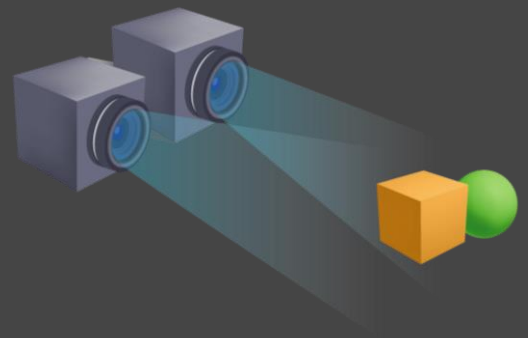
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Existing 3D Imaging Solutions
现有的三维成像解决方案

MultiVu®

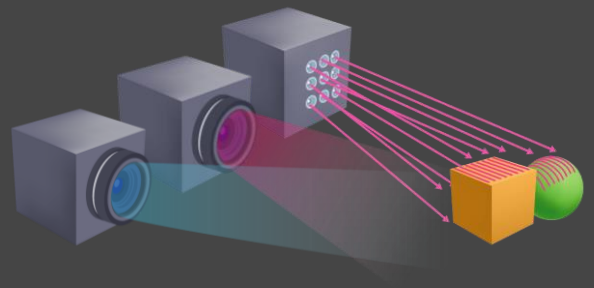
Stereo Vision

- Extracts depth information by triangulation
- Can use a pattern projector to add texture
- Suffers from occlusion – object seen by one camera but not the other



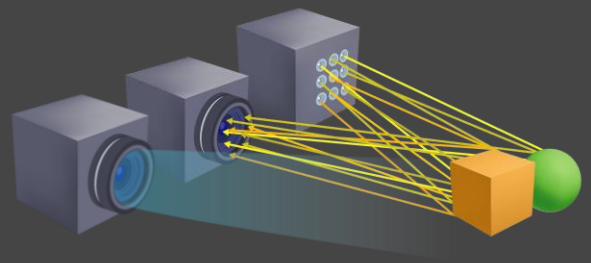
Structured Light

- Projects a NIR pattern on the object. Uses the pattern distortion on the object to reconstruct the object shape
- Higher accuracy but requires calibration and resolution limited by light source



Time Of Flight

- Measures time it takes for the emitted light to be reflected.
- Light source is NIR
- Multipath – emitted light is reflected from more than one path



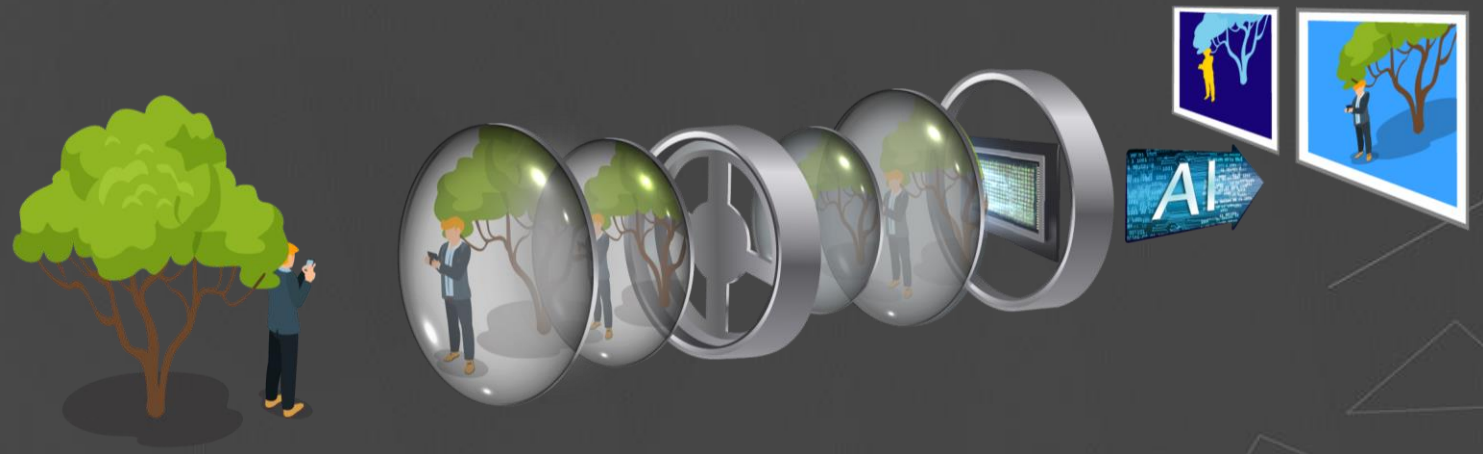
MultiVu®

MultiVu®'s Technology
MultiVu公司的技术

MultiVu®

MultiVu®'s 3D Imaging Solution
MultiVu公司的三维成像解决方案

MultiVu® is developing a single sensor 3D imaging solution, which can take color and depth images and function as a traditional camera with enhanced features

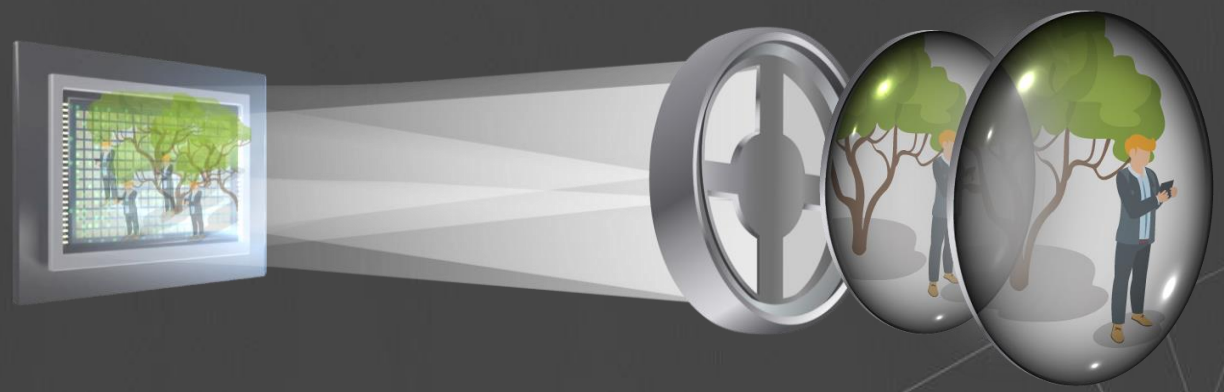


MultiVu®

The Technology Principle
技术原理

The technology is comprised of 3 elements:

1. A proprietary lens design with 4 apertures resulting in 4 viewpoints.
2. The light propagating via each aperture is projected on the full sensor
3. Reconstruction via AI



NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Another Alternative Approach for Navigation in a KNOWN environment
在已知环境中进行导航的另一种替代方法

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

https://www.youtube.com/watch?v=NWOqbUc1D3U&feature=youtu.be

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Discussion 讨论

- MultiVu facilitates 3D vision in near range with **no a-priory** knowledge
- RobotAI can navigate with **a-priory** knowledge
  - Robot arm to grab a part – a complex 6 DOF problem
- Lidar is good for long range and in not too populated environment
- An effort is on going in a European project to get the best of all worlds Multi Moby

NANOMOTION
A Johnson Electric Company

JOHNSON ELECTRIC
innovating motion

Multi Moby

Unique Features of the Nanomotion Velox Payload
Nanomotion Velox Payload产品的特有功能

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

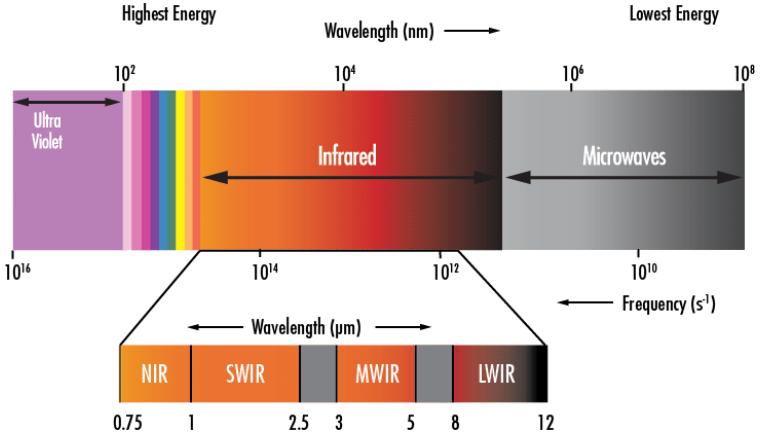
NANOMOTION
A Johnson Electric Company

JOHNSON ELECTRIC
innovating motion

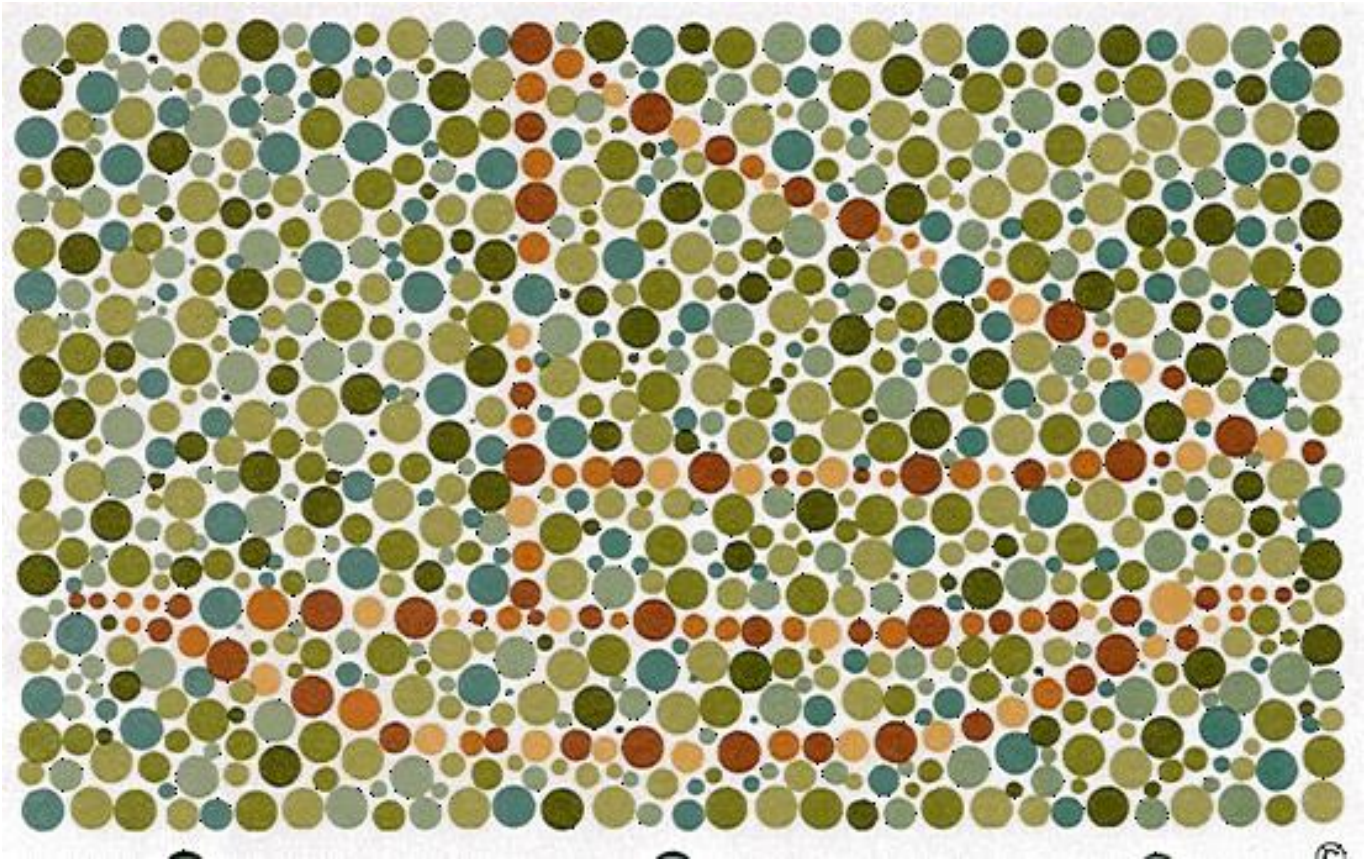
Imaging Sensor Types
图像传感器的类型

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- Electromagnetic spectrum
- The most used image sensor is CMOS in the Visible and NIR range
  - Requires illumination
  - Doesn't work in bad conditions
    - Rain
    - Fog
    - Dust
- Thermal image 3-5 micron, 8-12 micron – MWIR and LWIR
- SWIR, a novel approach



Who Sees the Boat?
能看到图中的小船吗?

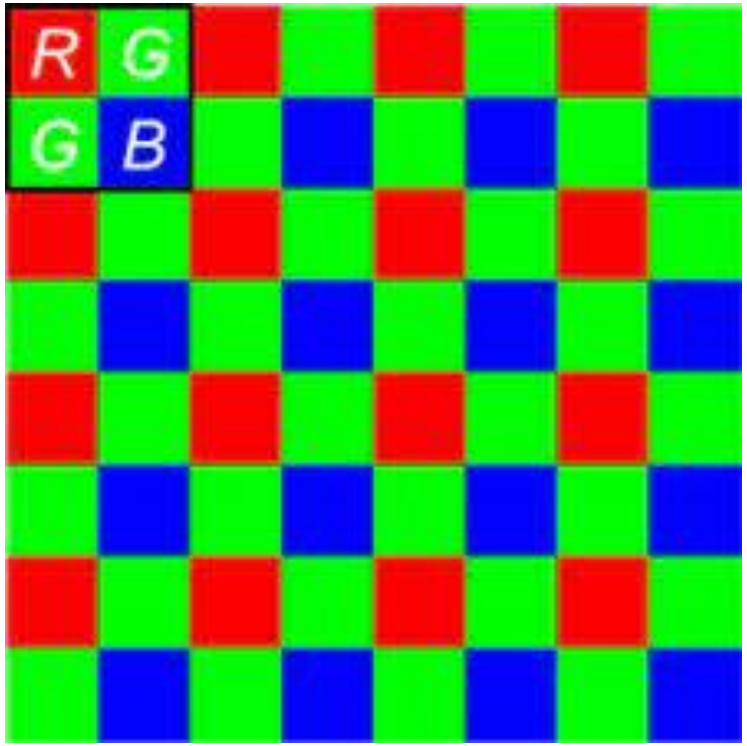


NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Bayer Filter In Color Camera
彩色相机中的拜耳滤光片

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- Pixels are coded by color filters



NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Color Vision 色觉

- Helps in detection recognition and identification
- The Human eye has sensors in Red, Green, Blue
- Birds have and additional sensor for improved perception in the Yellow
- Dogs do not see Red
- Bees can see UV
- Imaging system offer color analysis
- Nanomotion offers modules for that

Analytics 分析

- Amounts of data are huge
- Needs Big Data Analytics

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

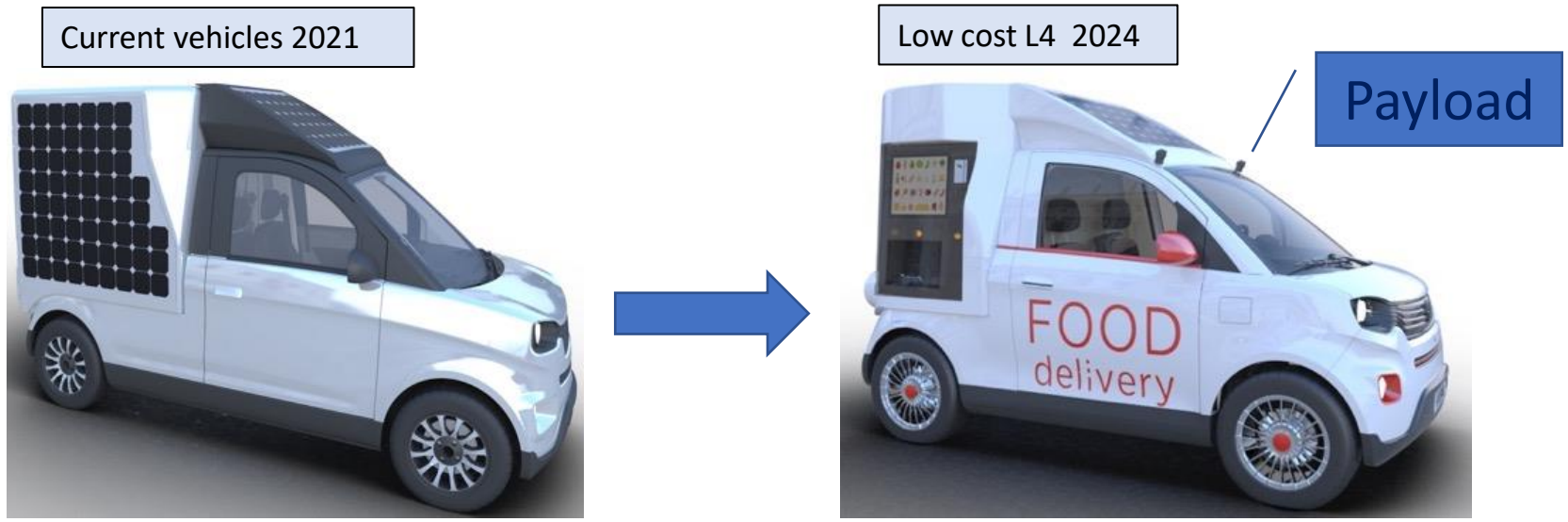
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Multi Moby Sensors
多个Moby传感器的使用

- Aiming at future sensing suites for affordable high performing fully autonomous vehicles
- Rather than using expensive and high computational demanding sensing suits based on a multitude of cameras, lidars and radars, **it is proposed vehicles to be equipped with “system-eyes”**
- The “system-eyes” like in every animal head are capable to rotate and are also capable to see in the infrared spectrum
- Each eye has a pre-processing capability and is adapting to the illumination of the environment
- AI brain with adaptive learning

Towards Low-Cost Autonomous Vehicles
朝向低成本发展的自动驾驶车辆

NASS
Dr. Nir Karasikov
Technology and Business Consultancy



EU project Multimoby Grant Agreement **101006953**.

NANOMOTION
A Johnson Electric Company

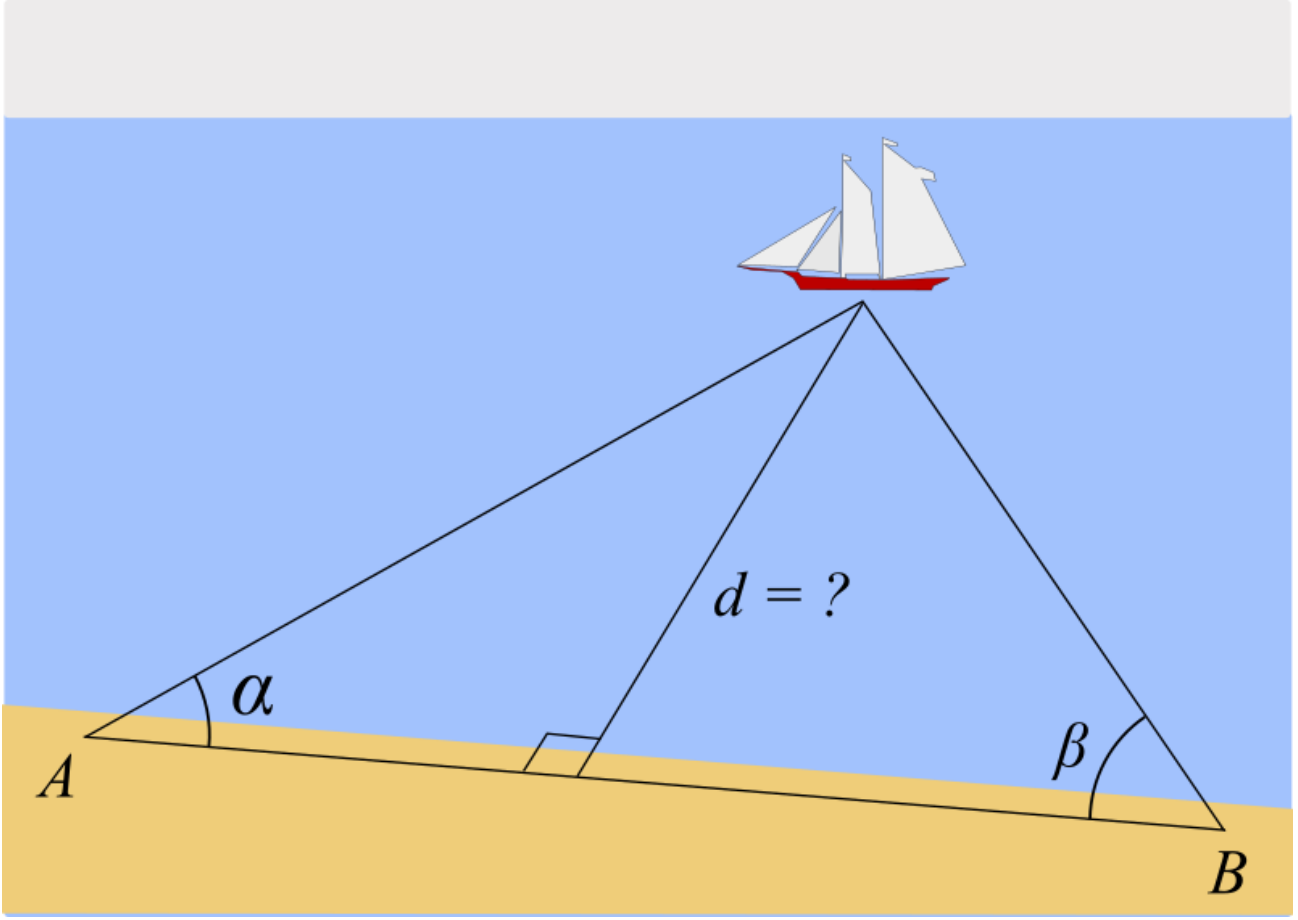
JOHNSON ELECTRIC
innovating motion

Multi Moby

Depth Measurement by Parallax
通过视差进行深度测量

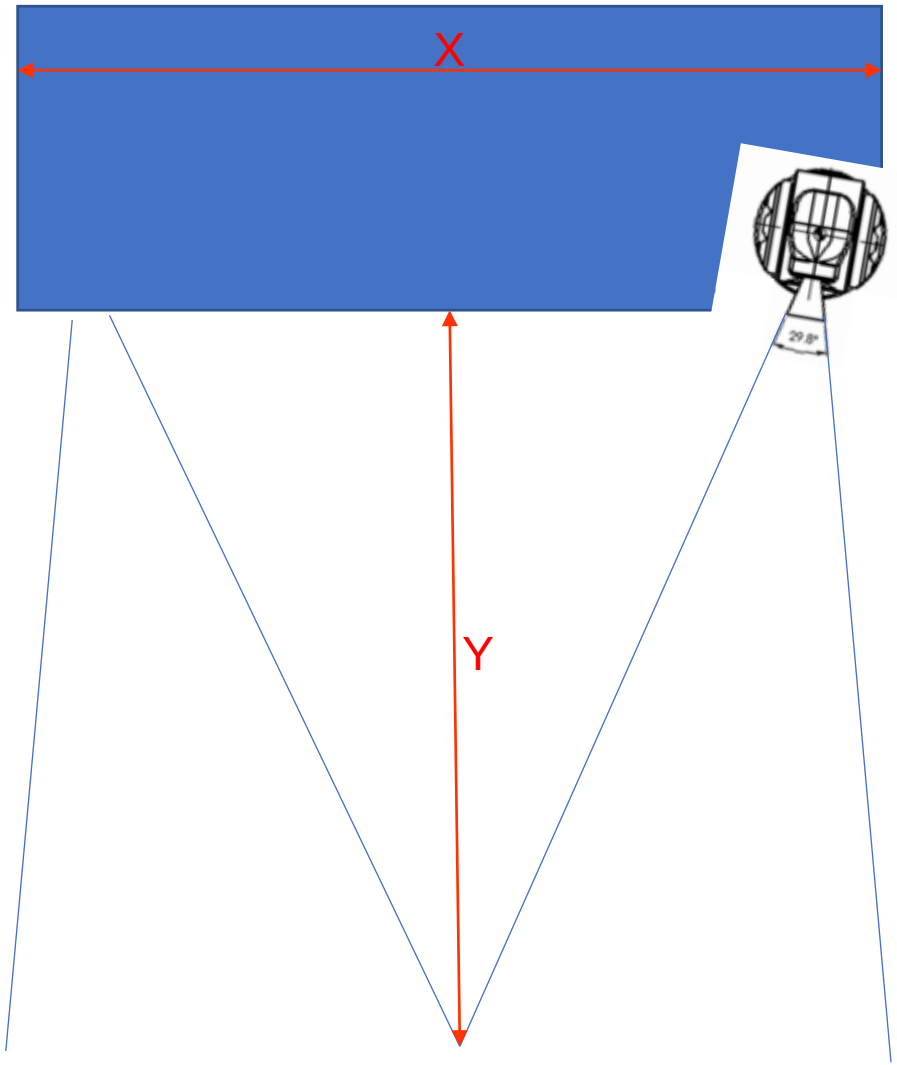
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- Angel proportunal to distance
- Accuracy increases when approaching



3D Vision 三维视觉

NASS
Dr. Nir Karasikov
Technology and Business Consultancy



- Present: With ~30º FOV and gimbals slightly turned toward the center: X ≈ Y
- While for 3D the gimbals intuitively should be bore-sighted, due to the high angular accuracy the 3D information can be retrieved also when looking inwards
- Panorama function and optimized lens FOV can cover near and far objects

- **Combine with MultiVu technology and algorithms**
- **Future!**

Stereo Reconstruction 立体重建

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Input Data

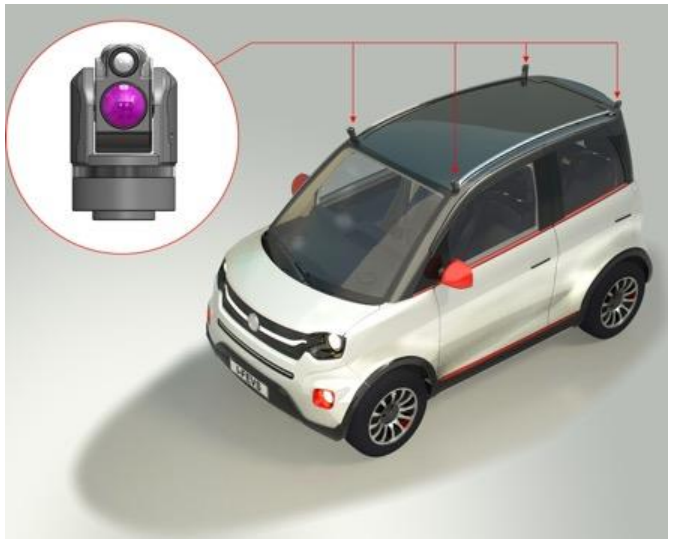
Super Imposed for Known Spacing
已知间隔的叠加

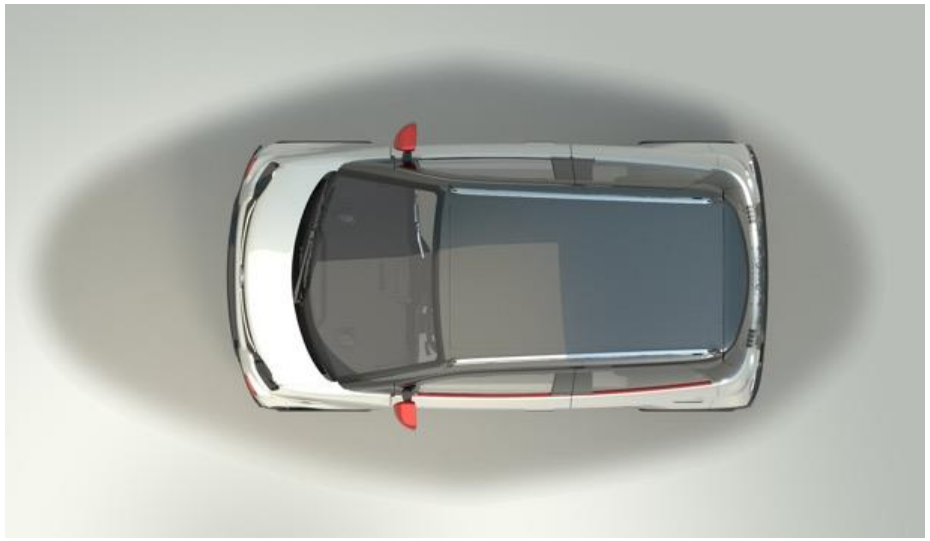
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

3D Reconstruction 三维重建

NASS
Dr. Nir Karasikov
Technology and Business Consultancy





Simplicity is the last sophistication: Leonardo da Vinci

Multi Moby

Stabilization 稳定性

- Imaging require Image Stabilization
- Low Light Level require Mechanical Stabilization

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

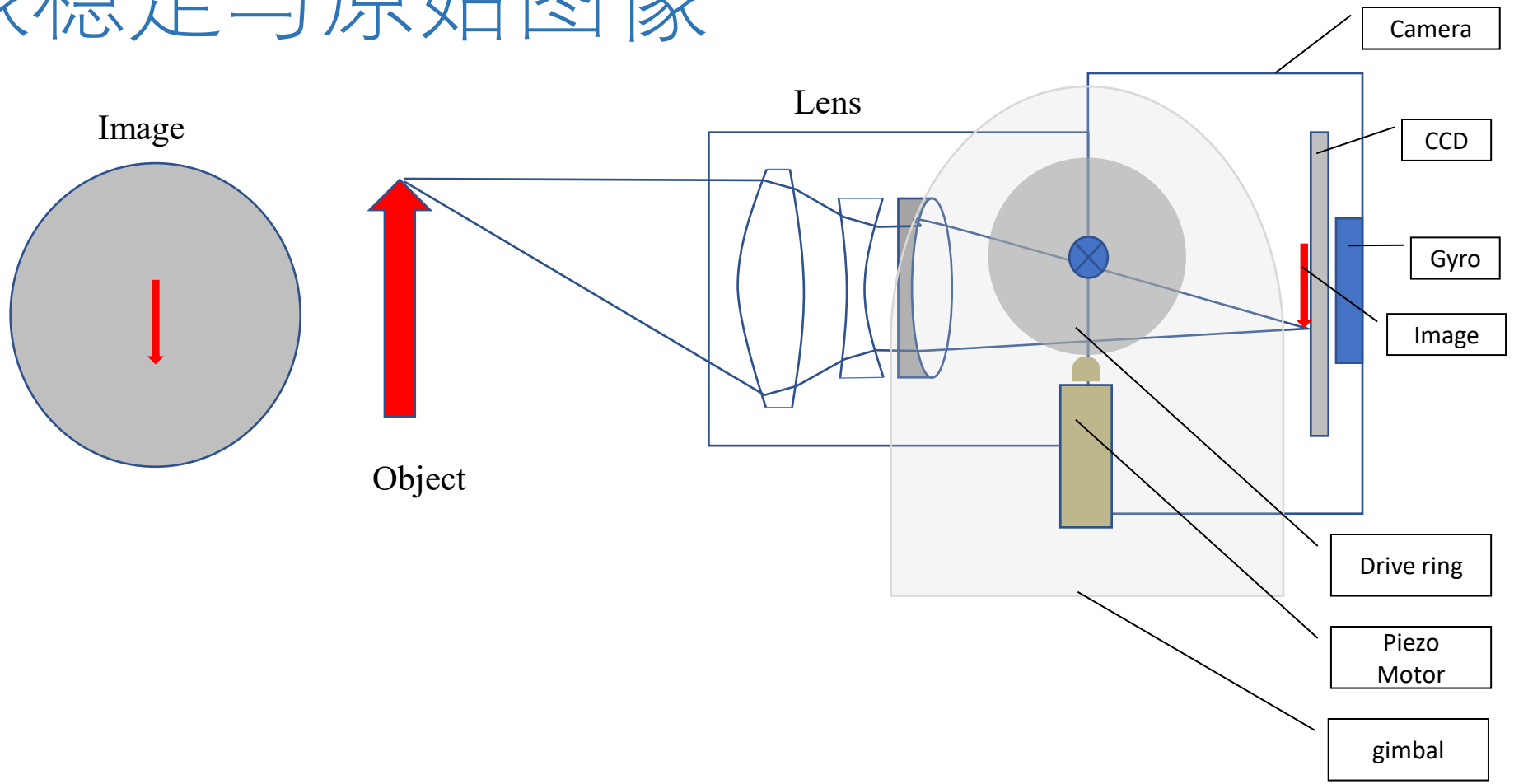
Mechanical Image Stabilization
机械图像稳定性

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- Important in Low Light Level conditions where integration time is long
  - In frame blur
- Important for Thermal Imaging
- Important for high magnification optics
- Important for Laser stabilization

Image Stabilization – Original Image
图像稳定与原始图像

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

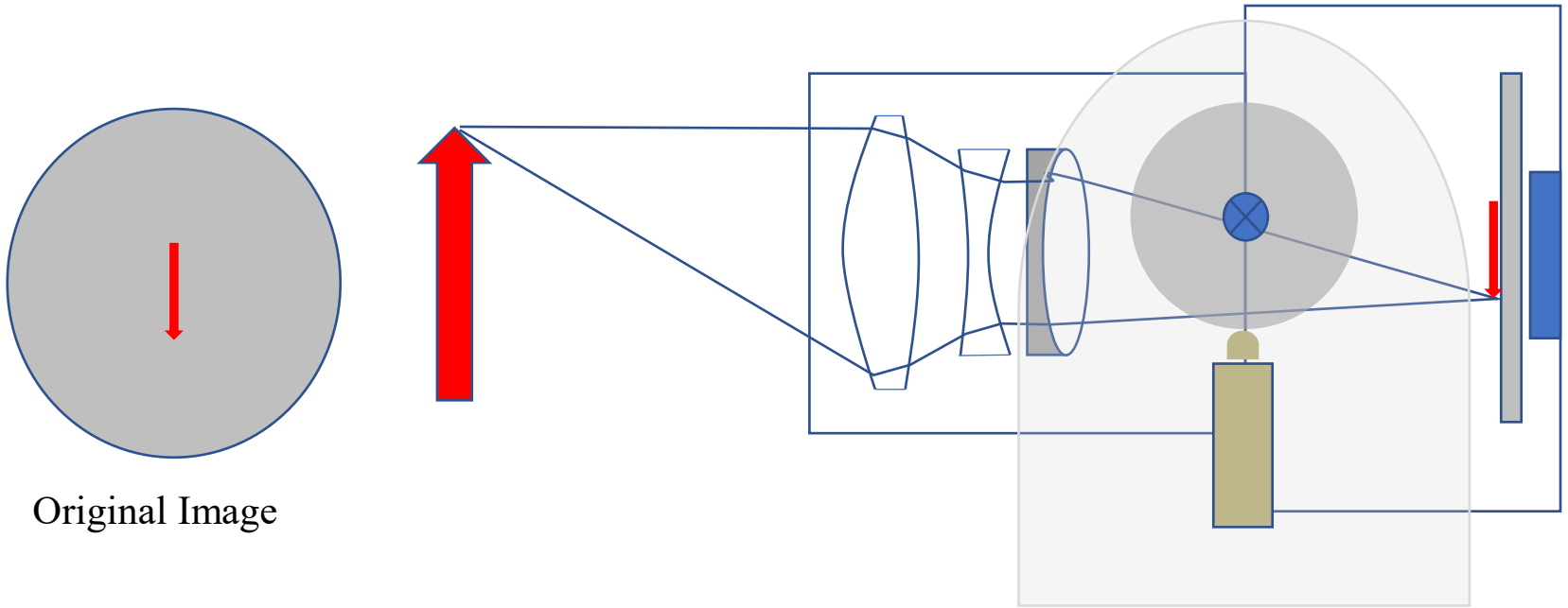


NANOMOTION
A Johnson Electric Company

JOHNSON ELECTRIC
innovating motion

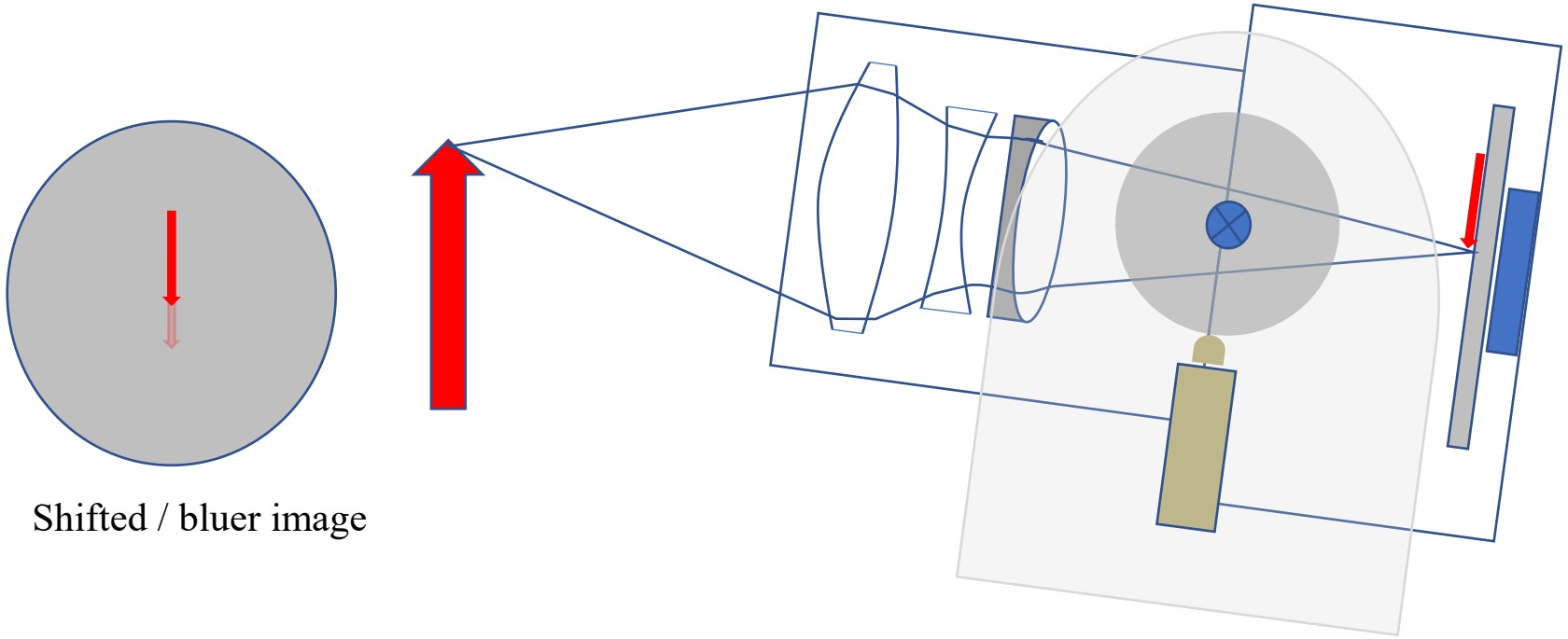
Image Stabilization – Original Image
图像稳定与原始图像

NASS
Dr. Nir Karasikov
Technology and Business Consultancy



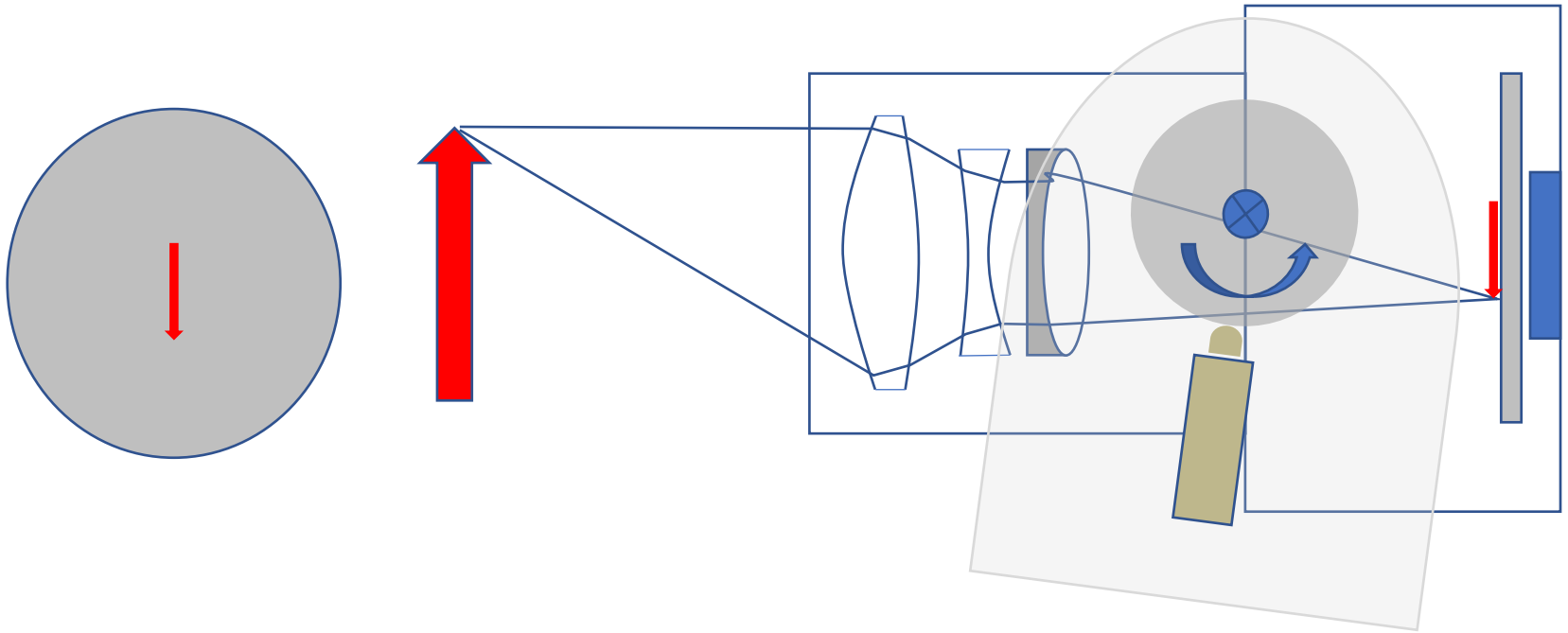
Original Image

Image Stabilization – No Correction
图像稳定与无校正



Shifted / bluer image

Image Stabilization – Gimbal Axis Correction
图像稳定与云台轴校正



NANOMOTION
A Johnson Electric Company

JOHNSON ELECTRIC
innovating motion

Payload Panoramic View – Inertial Stabilization and Non-Inertial Motion

Payload摄像头全景视图中的惯性稳定和非惯性运动

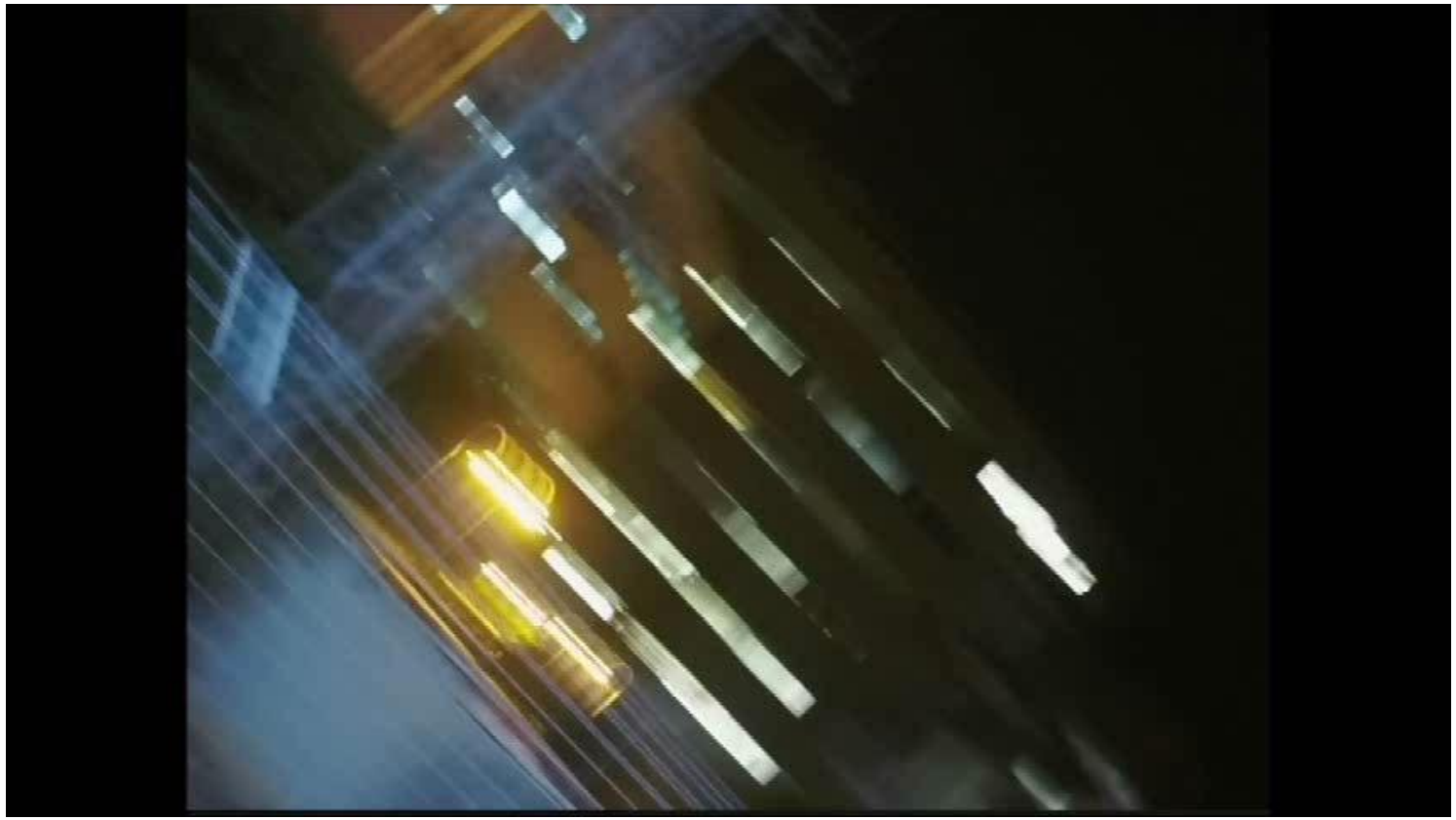
Panoramic scene capture while stabilizing on a vibrating platform

Velox Active Stabilization
Velox的主动稳定

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Day Camera, at night

The distance to target is 100m



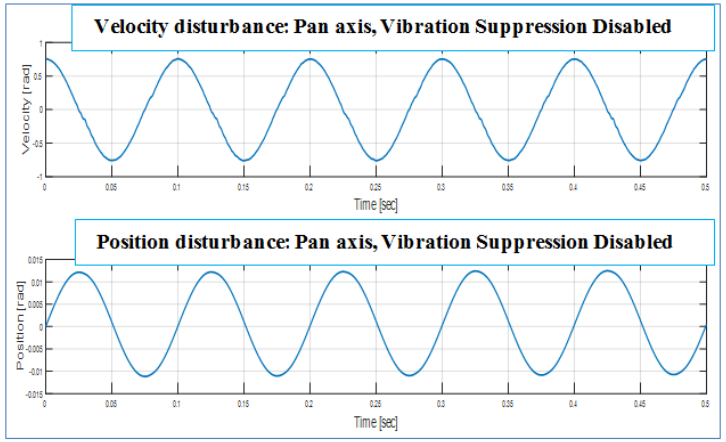
Velox Active Stabilization
Velox的主动稳定

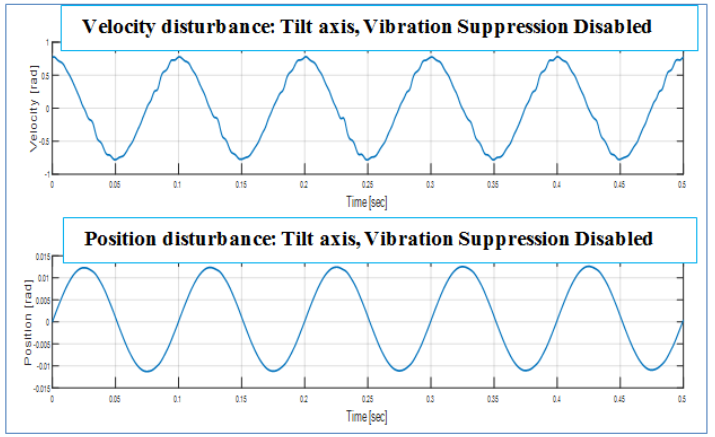
NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- Testing of the Gimbal Vibration Suppression Algorithm

Disturbance: Rotary Base stage rotating ±1 degree at a frequency of 10 Hz

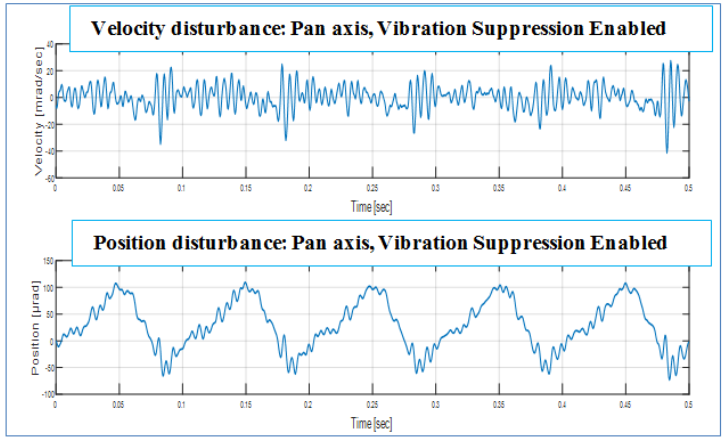
Vibration suppression Disabled

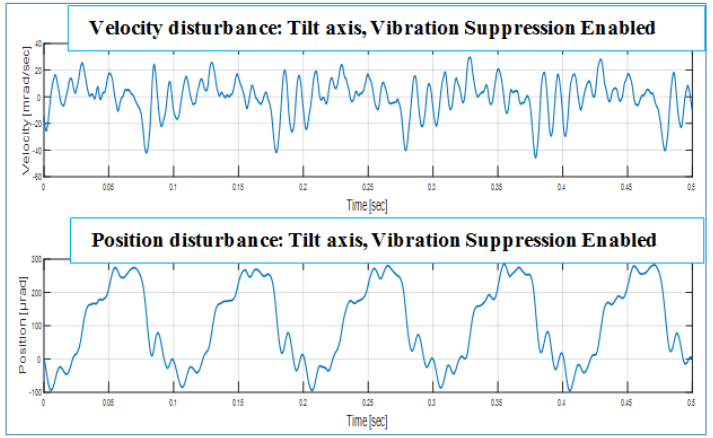




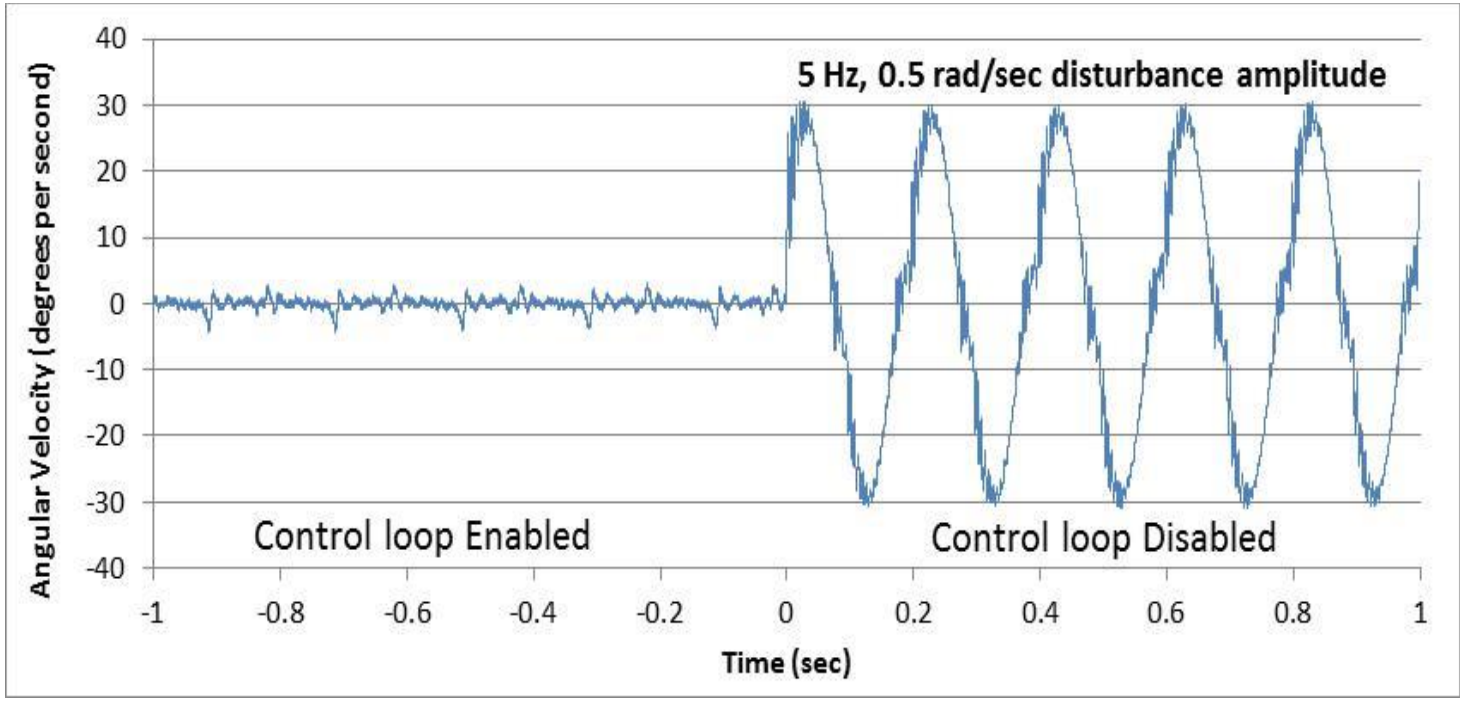
Vibration suppression Enabled

Stabilization to: 70 µrad rms @ 100ms,





Stabilization Results 5Hz @ 28 °/sec
在5赫兹28度/秒频率下的稳定结果



NASS
Dr. Nir Karasikov
Technology and Business Consultancy

NANOMOTION
A Johnson Electric Company

JOHNSON ELECTRIC
innovating motion

I-BIKE 3 wheels

Frame	super high strength steel
Length	200 cm
User height	165-195 cm
Wheels	24" (front) - 2x20" (rear)
Motor	85 Nm motor
Brake Kit	Hydraulic Disc Brakes
Drivetrain	Single-speed drivetrain
Solar assistance (optional)	up to 25 km
Battery pack	36V - 650Wh Lithium-ion battery
Range	up to 70 km
Assisted maximum Speed	25 km/h (for Europe)
Weight	32 kg

I-FEVS

INTERACTIVE FULLY ELECTRICAL VEHICLES

SAFETY | AFFORDABILITY | ERGONOMICS

EFFICIENCY | INTERACTIVITY | SUSTAINABILITY

I-BIKE 2 wheels

mem.com.mt

Frame	super high strength steel
Length	175 cm
User height	165-195 cm
Wheels	24"
Motor	85 Nm motor
Brake Kit	Hydraulic Disc Brakes
Drivetrain	Multi-speed drivetrain
Solar assistance (optional)	up to 25 km
Battery pack	36V - 550Wh Lithium-ion battery
Range	up to 70 km
Assisted maximum Speed	25 Km/h (for Europe)
Weight	26 kg

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Special Cases
一些特殊案例

- Bike on 3 wheels
- Can Stand still
- Can follow
- Fully connected
- Last mile delivery
- Solar panels

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

I-FEVS
INTERACTIVE FULLY ELECTRICAL VEHICLES
SAFETY | AFFORDABILITY | ERGONOMICS
EFFICIENCY | INTERACTIVITY | SUSTAINABILITY

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Self Driving Bike 自动行驶自行车

- https://youtu.be/LSZPNwZex9s

Summary 总结

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

- A diversity of considerations for autonomous systems were outlined
- While Level 5 AV is still a dream, some applications like AGV, UAV, Guided bikes are emerging
- A disruption using payload, advanced sensing and advanced algorithms was presented
- Last mile, clean environment, urban areas and safety are all triggers for advanced solutions for Intelligent Driving

Thank You
谢谢大家

NASS
Dr. Nir Karasikov
Technology and Business Consultancy

Nir.karasikov@gmail.com +972 52 8113311