Autonomy and AI for Advanced Transportation Technologies

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NORTH CAROLINA AGRICULTURAL AND TECHNICAL STATE UNIVERSITY

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Transportation Infrastructure at NC A&T

- NC A&T has led several other transportation-related multi-university efforts
  - Center for Regional and Rural Connected Communities (CR2C2)
  - CATM - Tier 1 UTC
  - NC-CAV Center of Excellence on CAVs

Transportation Institute

CR2C2 Regional UTC

Center for Advanced Transportation Mobility

NC Transportation Center of Excellence on CAVs

Aggie Autonomous Auto (A3)

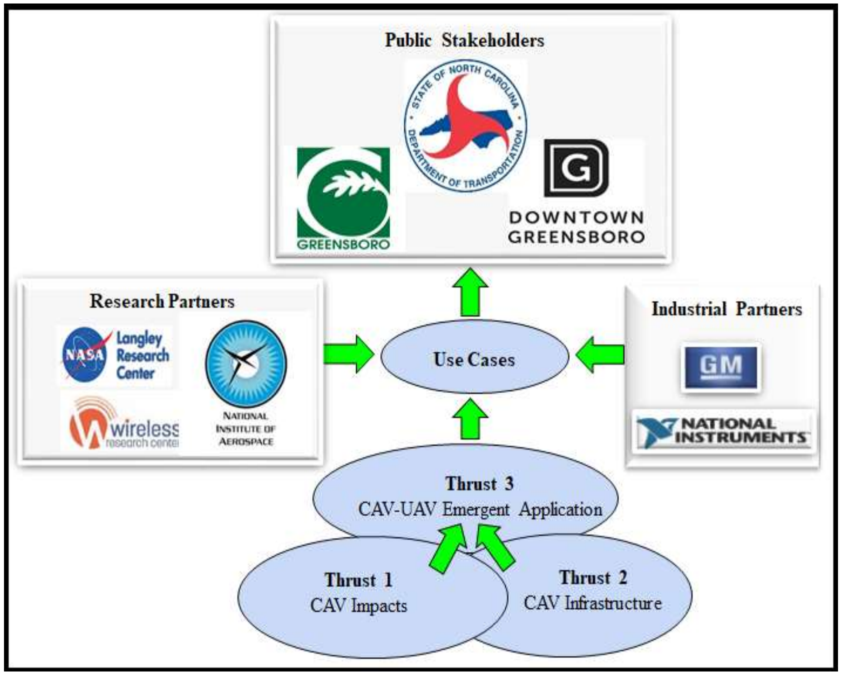
A dedicated rural test track at NCAT

The testbed of connected and autonomous micro-transit vehicles

A CAV HIL simulator

"NC-CAV Center of Excellence on Advanced Transportation Technology," Sponsor: North Carolina Department of Transportation (NCDOT), 2020-2025.

- **Thrust 1 (CAV Impacts)** investigates the impact of Connected and Autonomous Vehicle's (CAV) on North Carolina's transportation system and associated revenue.
- **Thrust 2 (CAV Infrastructure)** assesses North Carolina's readiness for CAVs in traditional and emerging transportation infrastructure.
- **Thrust 3 (CAV Applications)** explores emerging applications of CAVs and develops CAVs and Unmanned Arial Vehicles (UAVs) for advancing transportation systems.



The NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technolog (NC-CAV)

Goal: The primary goal of CR²C² is to plan, implement, and evaluate an integrated research, education, workforce development, and technology transfer approach for providing innovative connected and coordinated multimodal technological solutions for rural and underserved communities.

Adopting Emerging Transportation Technologies to Enhance Mobility of People and Goods in Rural and Under-served Communities

MRI 1 *Integrating emerging technologies into transportation planning and policy*

MRI 2 *Developing technological solutions for connected, safe, reliable, and secure transportation services*

MRI 3 *Providing equitable technology-driven mobility services*

Technology Development Infrastructure

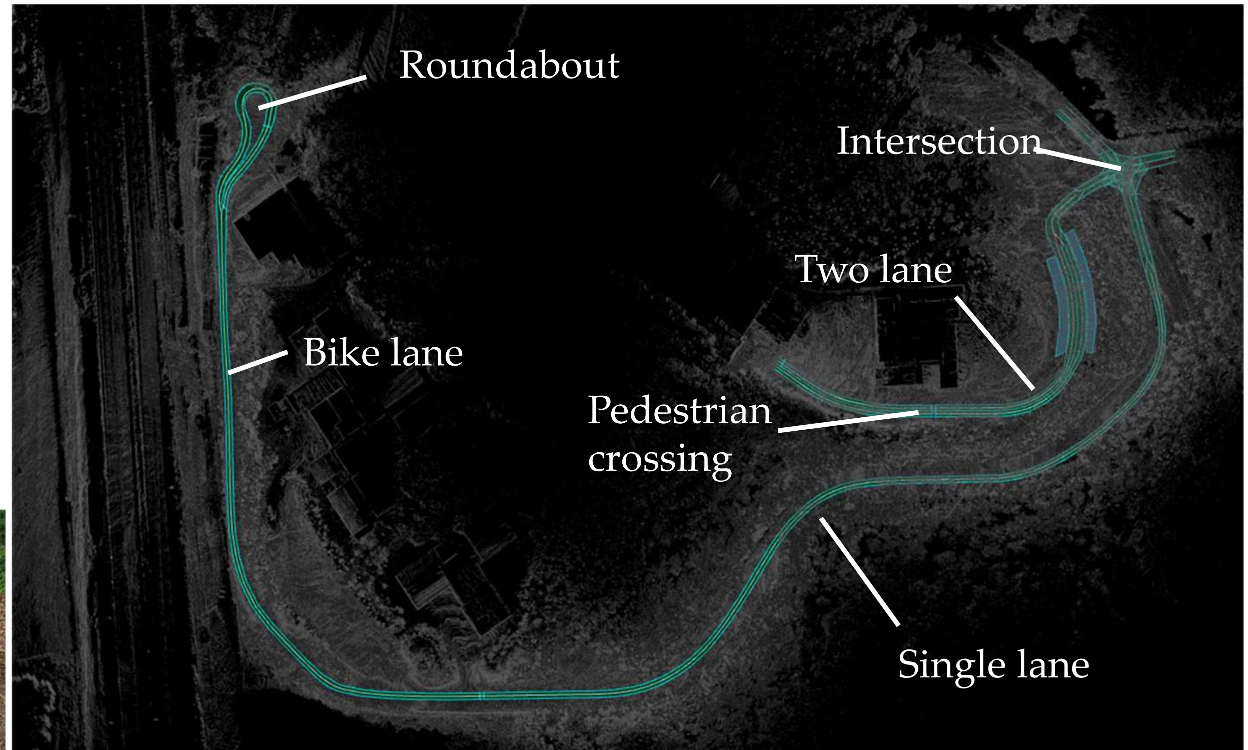
A dedicated rural test track at NCAT

The testbed of connected and autonomous micro-transit vehicles

A CAV HIL simulator

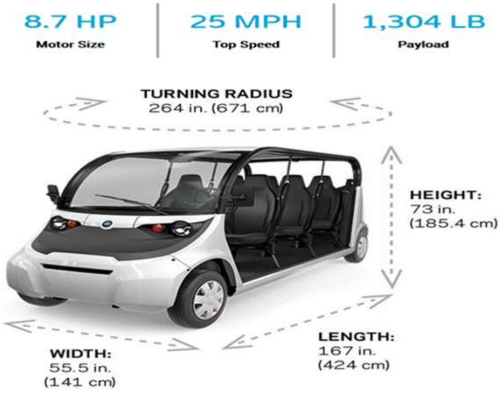
Roadway and Traffic Features

- Narrow road
- Steep Hills
- Forest environment
- Solid /Dash line
- Roundabout
- Intersection
- Regulatory/Warning Signs
- Bicycle lane
- Bus stop
- Pedestrian crossing



Autonomous Car Testbed

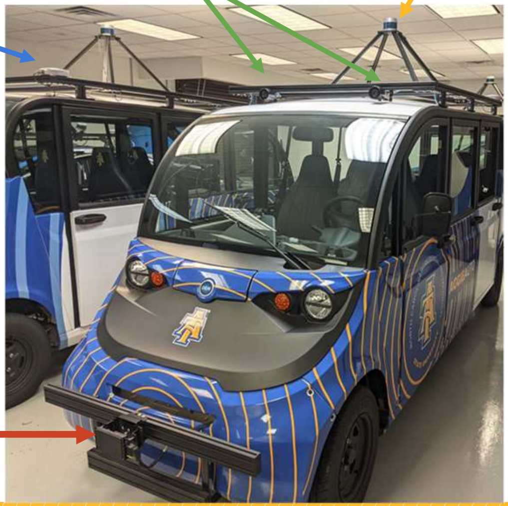
Autonomous Car Testbed



Camera Detection

LIDAR Detection, Localization

GPS Ant Localization

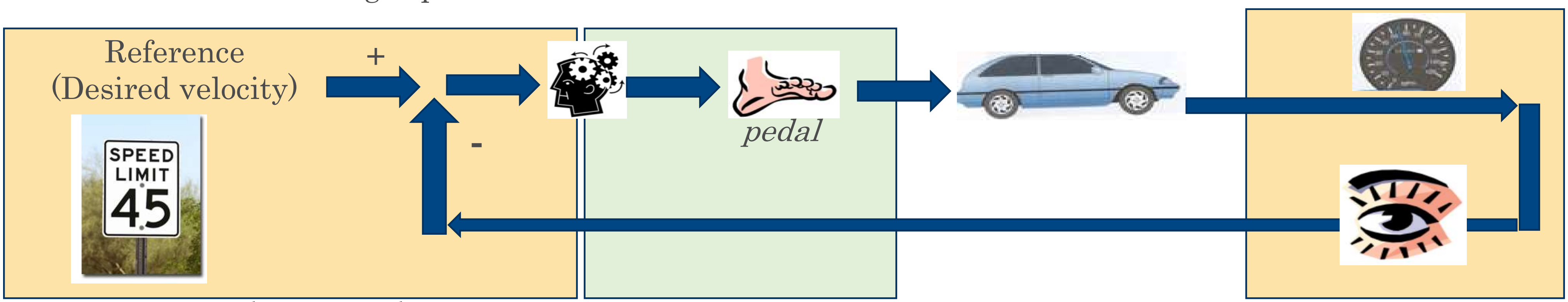


RADAR Detection

How to control a system?

- Let's take a lesson from human experience!
- How does a driver control the car velocity?

➢ Eyes look at the velocity gauge.
➢ Brain compares the car velocity with the desired velocity and computes the gas pedal position.
➢ Foot actuates the gas pedal.

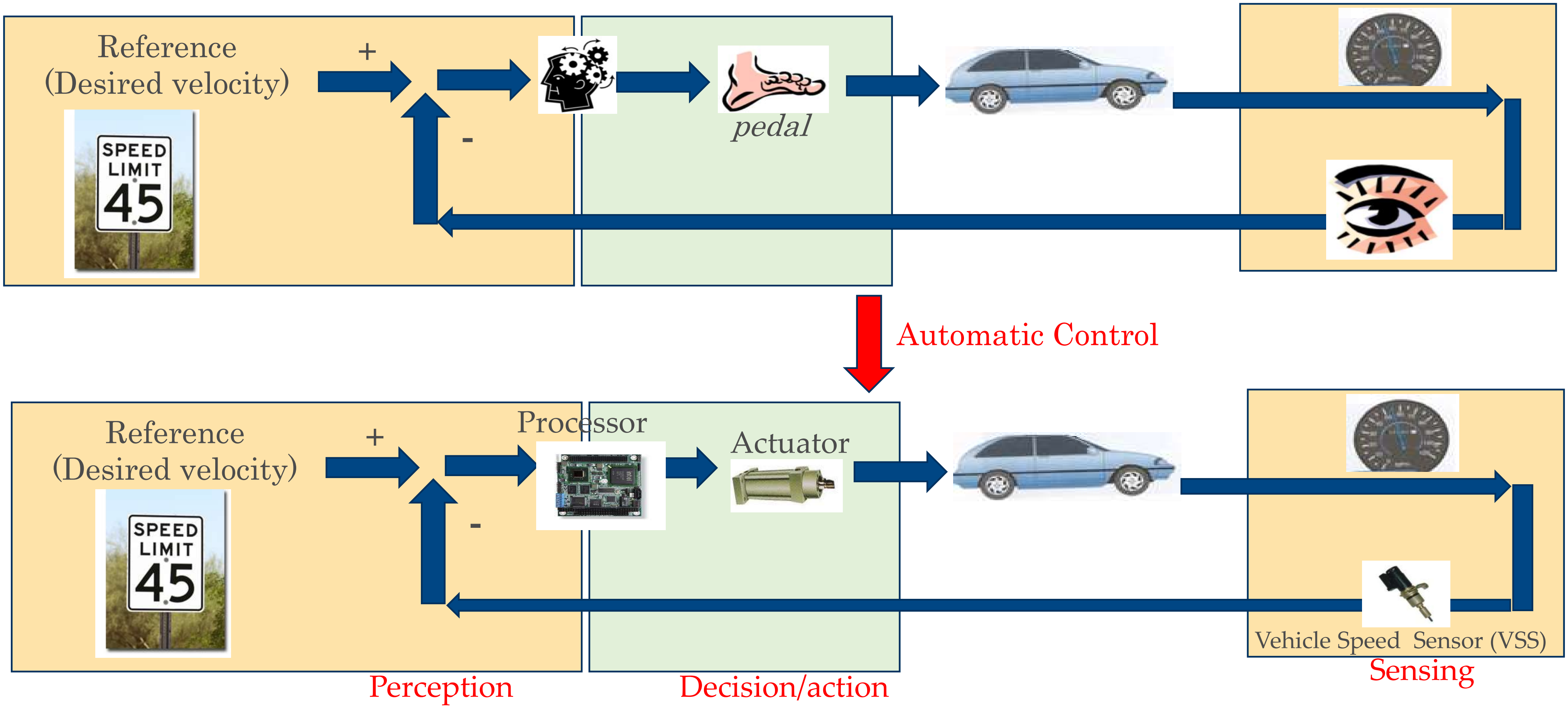


Process and Perceive the situation

Macke decision and take action

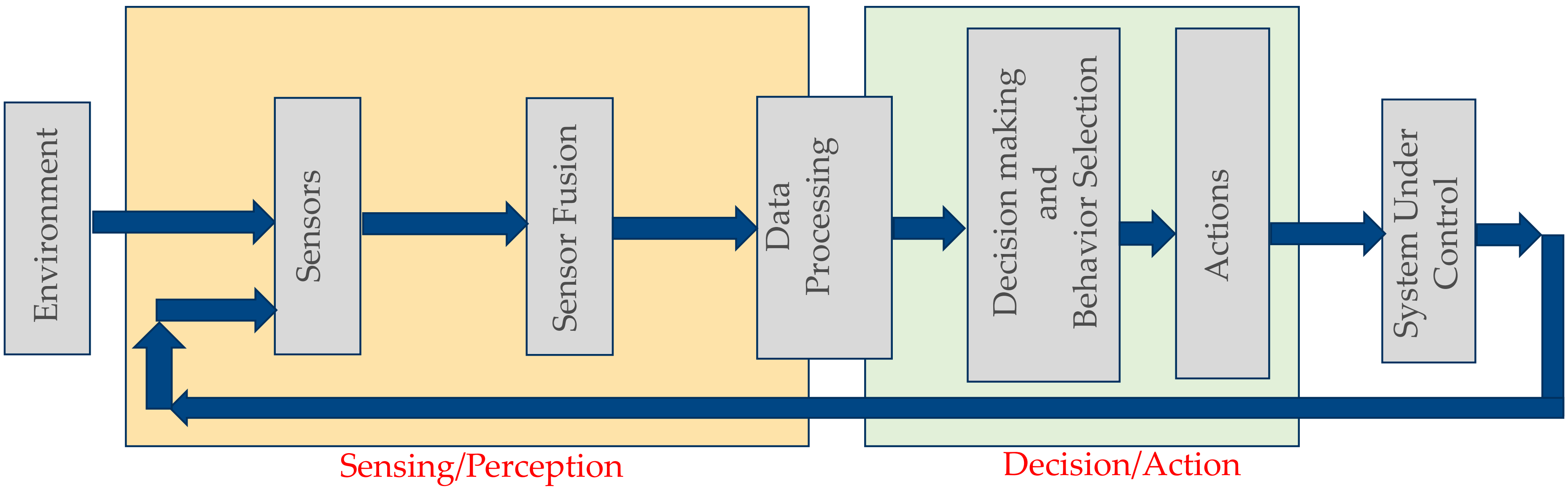
Sense/observe the car velocity

From Perception to Decision: Automatic Control

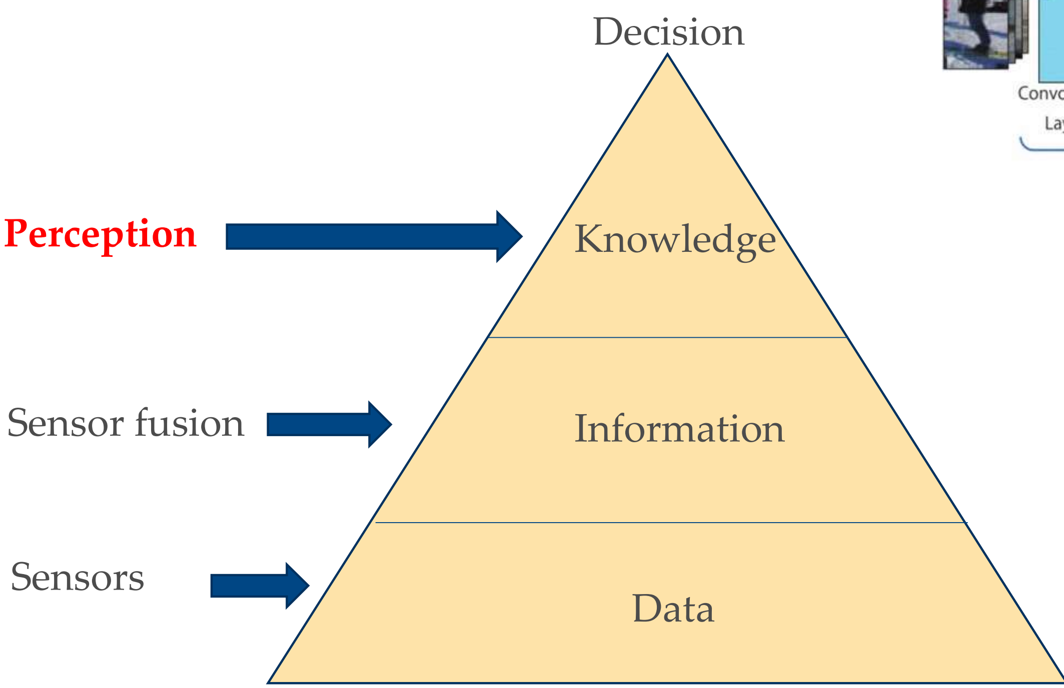


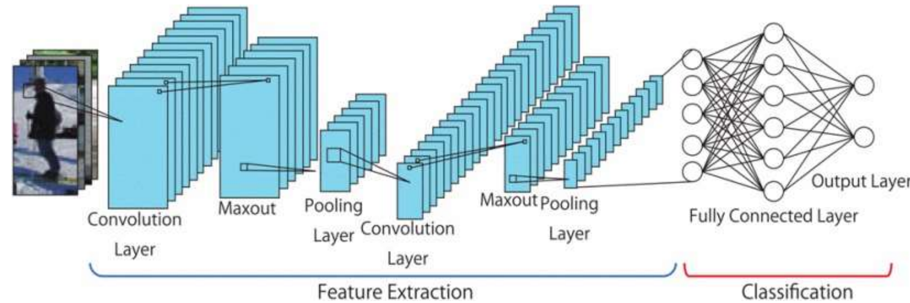
https://youtu.be/QquTxzKOo7Y

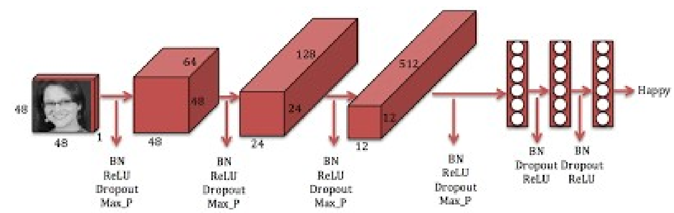
From Perception to Decision: Information Flow



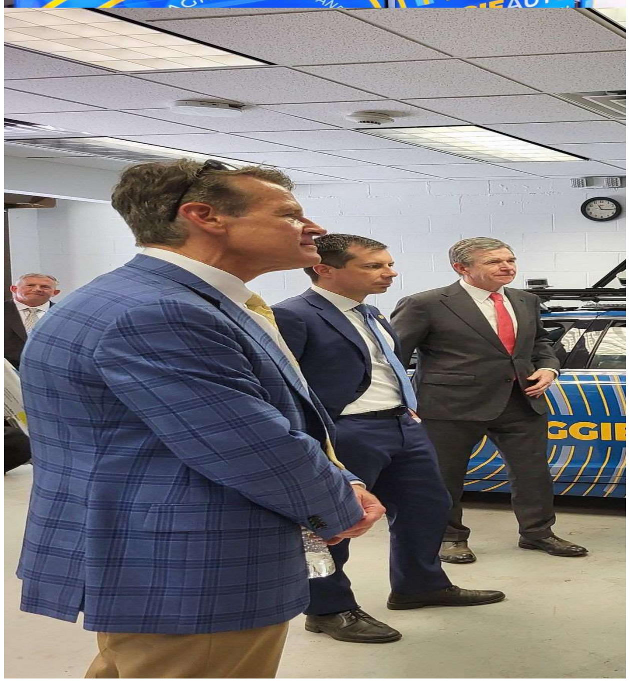
Perception


Decision
Perception
Knowledge
Sensor fusion
Information
Sensors
Data


Convolution Layer
Maxout
Pooling Layer
Convolution Layer
Maxout
Pooling Layer
Fully Connected Layer
Output Layer
Feature Extraction
Classification


Happy

https://youtu.be/C0Nt2xFoZeo




intel verizon

SAE International AutoDrive Challenge
June 12 at 9:00 AM ·

Congratulations to all 8 universities!

AutoDrive Challenge™ Competition Year 2- Results

Place	Team Number	University	Total Points
1	16	Univ of Toronto	884.96
2	14	North Carolina A & T State Univ	522.98
3	15	Texas A&M Univ	515.10
4	13	Michigan Tech Univ	470.79
5	11	Kettering Univ	437.11
6	18	Virginia Tech	429.77
7	12	Michigan State Univ	351.73
8	17	Univ of Waterloo	330.23

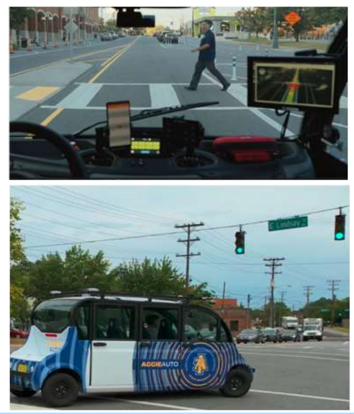
- ***Overall 2nd in the Competition***
- 3rd in Mapping challenge
- 3rd in Bill of Material
- 3rd in Pedestrian detection challenge
- 2nd in Intersection challenge
- 2nd in Straight line challenge
- 2nd in Mcity challenge

Bringing innovation from the lab space to public streets

Complexity

Laboratory Testing

Closed-Track Testing



Public Street Testing

Giving Rides to the Public on Public

Public Deployment of Aggie Auto Shuttles


North Carolina Agricultural and Technical State University
NCAT.EDU
North Carolina Agricultural and Technical State University
EXIT

Developing Workflow, Implementation Tools, and Guidance for Efficient UAV-enabled Bridge Inspection

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Background

- Bridges play a crucial role in transportation systems
- National Level Statistics:
  - 616,096 bridges in the United States with 42 percent aged more than 50 yrs.
  - 7% of bridge failures due to deterioration of Concrete, Steel, Pier, Pile, & Abutment etc.
- State Level Statistics:
  - There are about 13,500 bridges across the State of North Carolina (NC) highways.
  - About 13% of the bridges in State of North Carolina are structurally deficient. This is higher than the nation's 9.1% structurally deficient bridges for a letter grade of C+.
- Inspection Requirements::
  - All bridges should be regularly inspected by North Carolina Department of Transportation (NCDOT) at least every two years.
  - These structurally deficient bridges are still safe to be used, but they require much more aggressive inspection and extensive inspection and maintenance plans to remain in service.

Rodanthe Jug Handle Bridge, Rodanthe - NC

Neuse River Bridge, New Bern - NC

Current Bridge Inspection Method

1. **Cost and Time:** Often require specialized equipment, and lengthy inspection procedures. This can result in significant time and cost implications.
   - *FHWA reportedly quotes a bi-annual expenditure of $2.7bn.*
   - *NCDOT estimates $4,600 for a 2-Man 8 hour inspection with lane closure*
   - *FHWA reported approximates an average of 1-2 days for an inspection*

2. **Limited Visual Inspection:** Inspectors may not be able to access certain areas due to structural complexity or safety concerns, leading to potential blind spots in the inspection

3. **Subjectivity and Variability:** Different inspectors may interpret defects or structural issues differently, leading to subjectivity and variability in the inspection results. *This can affect decision-making regarding maintenance, repair, or replacement of the bridge.*

4. **Safety risks:** Often require inspectors to work at heights and in potentially hazardous conditions using different access tools.

5. **Disruption to Traffic:** Bridge inspections often require lane closures or traffic diversions, causing inconvenience to road users and disruptions to traffic flow.

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Opportunities for UAV adoption

1. **Time and Cost Efficiency:** UAV-based inspections are typically faster and more cost-effective compared to traditional methods. UAVs can rapidly collect high-resolution images and videos, covering larger areas in a shorter period.

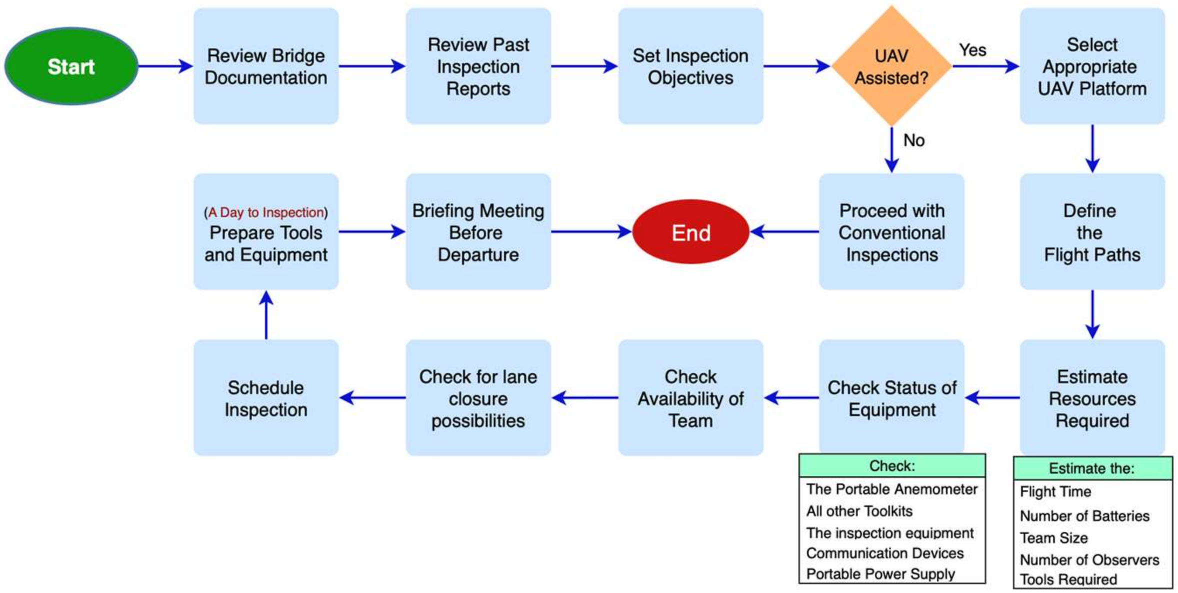
2. **Enhanced Safety:** UAVs eliminate or significantly reduce the need for inspectors to physically access hazardous areas of the bridge.
   - *By deploying drones, inspectors can remotely gather visual data and perform inspections from a safe location, mitigating risks associated with working at height or in dangerous environments*

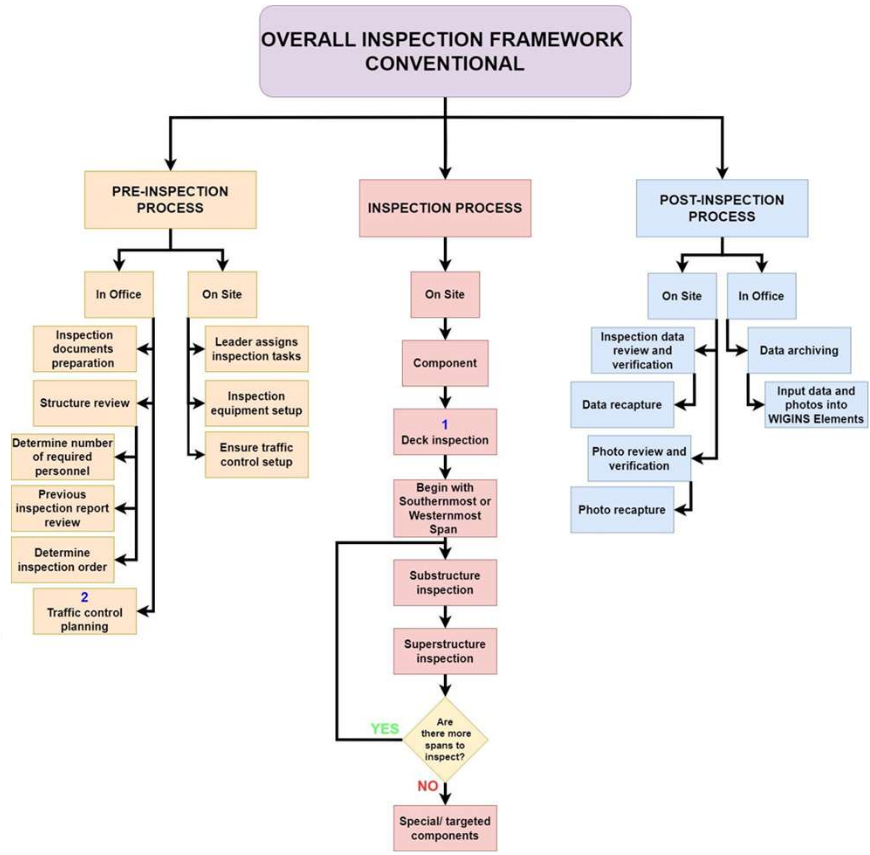
3. **Improved Accessibility:** UAVs can easily reach areas that are difficult or impossible for inspectors to access manually.
   - *They can navigate narrow spaces, fly over water bodies, and access the undersides of bridges, providing comprehensive visual coverage and reducing the likelihood of inspection blind spots*

4. **Repeatable Inspections and Comparison:** UAVs can be programmed to follow predefined flight paths and capture consistent data during subsequent inspections.
   - *This allows for easy comparison between inspection cycles, enabling inspectors to monitor structural changes, track deterioration, and assess the effectiveness of maintenance interventions over time.*

5. **Real-time Monitoring and Analysis:** UAVs can transmit live video feeds and data in real-time to inspection teams, enabling immediate analysis and decision-making.

6. **Data Management and Analytics:** UAV inspections generate large amounts of digital data that can be efficiently managed, stored, and analyzed.
   - *Advanced image processing, machine learning, and computer vision techniques can be applied to this data to automate defect detection, classification, and analysis, improving the accuracy and consistency of inspection results.*


Start
Review Bridge Documentation
Review Past Inspection Reports
Set Inspection Objectives
UAV Assisted?
Yes
No
Select Appropriate UAV Platform
Define the Flight Paths
Estimate Resources Required
Proceed with Conventional Inspections
End
Briefing Meeting Before Departure
(A Day to Inspection) Prepare Tools and Equipment
Schedule Inspection
Check for lane closure possibilities
Check Availability of Team
Check Status of Equipment
Check:
The Portable Anemometer
All other Toolkits
The inspection equipment
Communication Devices
Portable Power Supply
Estimate the:
Flight Time
Number of Batteries
Team Size
Number of Observers
Tools Required


OVERALL INSPECTION FRAMEWORK CONVENTIONAL
PRE-INSPECTION PROCESS
INSPECTION PROCESS
POST-INSPECTION PROCESS
In Office
On Site
Inspection documents preparation
Structure review
Determine number of required personnel
Previous inspection report review
Determine inspection order
2
Traffic control planning
Leader assigns inspection tasks
Inspection equipment setup
Ensure traffic control setup
On Site
Component
1
Deck inspection
Begin with Southernmost or Westernmost Span
Substructure inspection
Superstructure inspection
Are there more spans to inspect?
YES
NO
Special/ targeted components
On Site
In Office
Inspection data review and verification
Data recapture
Photo review and verification
Photo recapture
Data archiving
Input data and photos into WIGINS Elements


UAS-Enabled Solutions
for Bridge Inspection
https://www.uas4bridge.com
https://www.accesslab.net
Conducted by researchers at
NORTH CAROLINA A&T
STATE UNIVERSITY
UNC CHARLOTTE
Sponsored by
North Carolina Department of Transportation
STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

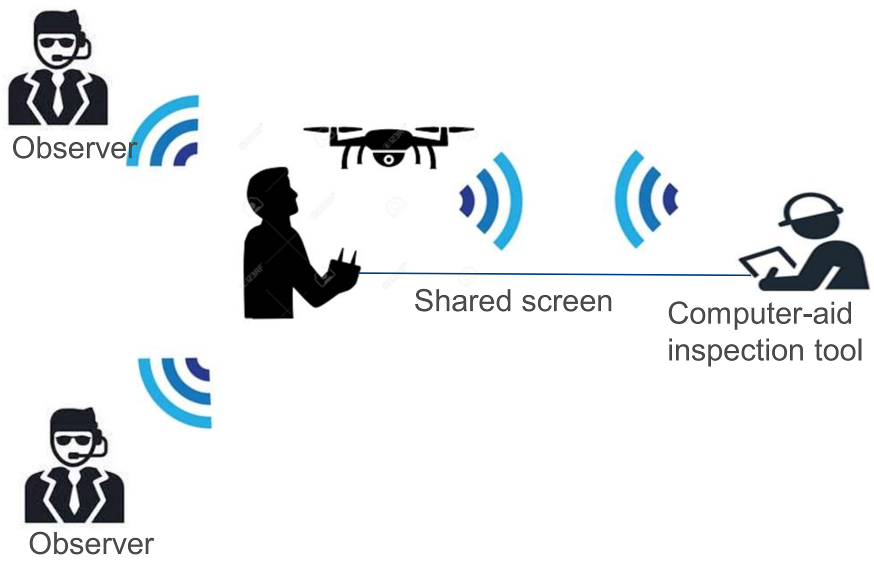
In-field inspection setups: Expert UAV Pilot but not a qualified Inspector

- **Pros**
  - Safety of the UAV platform is ensured

Cons

- Pilot-Inspection Team communication becomes difficult if both do not share the same experience, knowledge and terminologies and can affect inspection process and output
- High chance that the inspection has to be repeated as the pilot may not know the exact data that is needed to be collected.
  - Pilot may increase the quantity of collected data (data storage problem)
- Quality of collected data may be negatively impacted due to multitasking by the Pilot
- May negatively affect the inspection process and safety of the platform since the Pilot-in-Command (PIC) assumes multiple roles and attempts to multitask
- For new detection of defects in office (which could have been detected during the inspection), a follow-up in-person visit, and hands-on inspection is needed.

1. **Shared screen** for effectively having the inspector in the loop
2. **Effective communication** between the inspection team
3. **Computer-aid inspection tool**



Inspector-In-The-Loop
UAV-Assisted Bridge Inspection

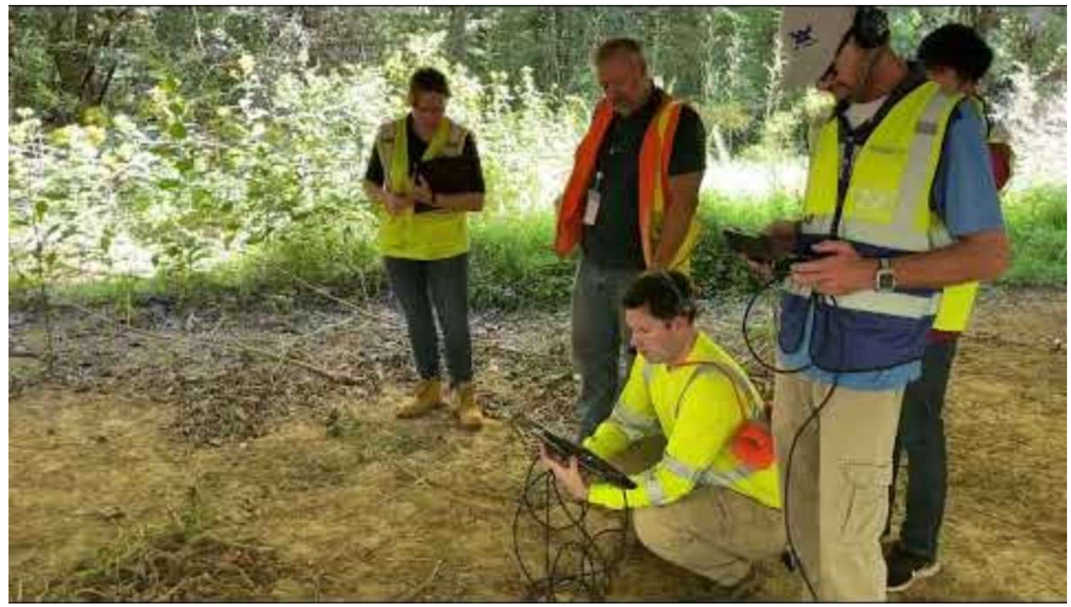
NC DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STRUCTURE MANAGEMENT UNIT

ATTENTION: (INSPECTED BY DRONE), PAR ISSUED

Structure Safety Report
Routine Element Inspection

STRUCTURE NUMBER: 890178 SAP STRUCTURE NO: 0900178 FHWA STRUCTURE NO: 000000001790178
DIVISION: 10 COUNTY: UNION INSPECTION DATE: 09/20/2022 FREQUENCY: 24 MONTHS
FACILITY CARRIED: SR1104 MILE POST:
LOCATION: 1.0 MI. N. JCT. SR1102
FEATURE INTERSECTED: WAXHAW CREEK
LATITUDE: 34° 51' 2.4" LONGITUDE: 80° 46' 26.65"

(DRONE PHOTO) TYPICAL BEARING UNDER BEAM 3 AT INTERIOR BENT 2



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Thank You

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State of North Carolina Department of Transportation