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Constraint-Driven Autonomous Vehicle Capstone: Interdisciplinary Best Practices

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Abstract

This paper presents a case study of an interdisciplinary capstone project at Florida Atlantic University and provides comprehensive guidance on navigating key challenges in undergraduate engineering education. As engineering problems grow increasingly complex, bridging the knowledge gaps between distinct technical disciplines is critical. Specific challenges are addressed related to team management, cohesive interdisciplinary communication, effective hardware-software systems integration, and the pedagogical handling of unpredictable technical constraints within a Problem-Based Learning (PBL) framework.

The interdisciplinary team was strategically composed of two computer scientists, one electrical engineer, and one computer engineer. Their objective was to develop an autonomous driving system for a ride-on vehicle under strict pedagogical constraints: using a single camera as the sole input, avoiding obstacles without human intervention, maintaining a low cost, and achieving real-time processing without computationally intensive Artificial Intelligence (AI) models. To satisfy these constraints, the team developed a custom architecture utilizing an NVIDIA Jetson Nano to execute visual looming algorithms, bridged via I2C to an ESP32 microcontroller for motor actuation.

Beyond the technical architecture, this paper foregrounds the interpretive educational insights of the student experience. Team dynamics, disciplinary silos, and integration challenges were rigorously evaluated using peer accountability reports and the Szatmary rubric for ABET outcomes. Technical success was ultimately validated by the prototype earning two awards at the required senior capstone showcase. By documenting the specific friction points between the team members, their disciplines, and the strategies used to overcome them, this work yields valuable best practices. It provides actionable recommendations for scalability, offering educators practical guidance on implementing similar constraint-driven, multidisciplinary capstone experiences across varying engineering curricula.

1. Introduction

Capstone projects represent a pivotal milestone in the engineering curriculum, serving as the bridge between theoretical academic training and professional practice. As the engineering industry evolves at an accelerated pace, there is an increasing demand for multidisciplinary teams capable of addressing complex, real-world problems [1]. Recent systematic reviews highlight that multidisciplinary collaboration is essential for preparing students to handle highly integrated systems [2]. Engineering accreditation bodies have reinforced this by requiring programs to demonstrate that students possess the ability to function effectively on teams that establish goals, plan tasks, and meet objectives [3].

Research analysis emphasizes that multidisciplinary capstone design courses provide a quantitative improvement in student development and collaborative skills [4, 5]. Furthermore, other studies argue that these projects serve as a vital tool for learning the subject matter, specifically helping technical students develop the analytical abilities of engineering students [1]. Specialized assessment tools are now frequently employed to measure the mastery of these outcomes within capstone sequences [6].

While many institutions integrate students late in their curriculum, case studies from diverse programs, ranging from newly established polytechnic universities to traditional engineering colleges, emphasize that the design-based approach is a highly effective tool for learning complex subjects [7, 8]. Robotics-themed capstones, such as "robot racer" projects, offer particularly rich environments for this type of learning due to the inherent need for coordination between software, electronics, and mechanical systems [9].

This paper presents a case study of a multidisciplinary capstone developed over two academic terms. The project named “Vision-Based Autonomous Driving System (ViBADS)” focuses on a constraint-driven autonomous vehicle designed to locate and avoid obstacles using a single sensor as the sole input, without the use of AI-powered systems. By prioritizing computational efficiency, affordability, and scalability, this work aims to provide a reproducible model for balancing strict technical constraints with interdisciplinary management to achieve high-level student development.

Developing an autonomous system for a ride-on vehicle requires a convergence of computer vision, embedded systems, and electrical power management. Consequently, the interdisciplinary team was strategically composed not just for collaborative experience, but as a technical necessity to address the project's distinct software and hardware challenges.

It is important to contextualize the perspective from which this case study is analyzed. The primary author served as a participant-observer, having completed this specific interdisciplinary capstone as an undergraduate computer science student before transitioning into doctoral research within the same field at Florida Atlantic University. This dual lens, experiencing the tight pedagogical constraints firsthand before evaluating them through a graduate research framework, provides a unique methodological advantage. It allows this manuscript to document not only the granular technical realities of hardware-software integration but also the authentic, lived experiences of the students as they navigated complex interdisciplinary barriers.

2. Course Methodology

The capstone sequence at Florida Atlantic University is structured as a two-term, year-long multidisciplinary design experience. This longitudinal approach allows for the transition from planning and design to implementation and testing, mirroring established pedagogical models for engineering student development [1].

To effectively prepare students for the complexities of modern, highly integrated systems, this capstone sequence was grounded in a Problem-Based Learning (PBL) framework. Rather than providing a standard robust sensor environment, the project imposed rigid pedagogical constraints specifically, limiting the input to a single camera and operating under a tight budget. These limitations were intentionally designed to push students beyond theoretical application and force genuine interdisciplinary collaboration. For instance, translating visual looming algorithms into physical motor actuation within these constraints could not be accomplished by a single discipline; it demanded constant, iterative problem-solving and cross-domain knowledge transfer among the computer science, computer engineering, and electrical engineering methodologies.

A. Phase I: Project Initiation and Conceptual Design

In the initial term, the curriculum focuses on foundational team dynamics and systems engineering. Pedagogically, this phase intentionally presents an ill-structured problem; rather than being handed a roadmap, students must negotiate their disciplinary boundaries to define the scope and identify the specific knowledge gaps required to meet the project's strict technical constraints:

- *Team Formation and Project Selection:* Students form groups (single and multidisciplinary) and select from a list of faculty or industry-sponsored projects to approximate exposure to real-world engineering challenges.
- *Scoping and Problem Definition:* Deliverables include individual and group assignments designed to identify technical constraints, select technology stacks, and establish effective communication strategies.
- *Project Management:* Teams must provide a preliminary timeline and participate in mandatory weekly advisor meetings to guarantee course objectives and customer requirements remain synchronized.

B. Phase II: Implementation, Integration, and Assessment

The second term shifts toward technical execution and rigorous progress monitoring. Within the PBL framework, this phase relies heavily on formative assessment and reflective practice; the iterative demonstrations and accountability reports force students to continuously evaluate their cross-disciplinary integration efforts and pivot when technical approaches fail.

- *Iterative Demonstrations:* The faculty requires three formal class demonstrations. These milestones drive teams to demonstrate incremental progress and defend technical decisions made since the previous presentation.
- *Individual Accountability and Agile Adjustments:* Weekly reports require each member to document two specific tasks, providing evidence of individual contributions to the collective goal. Unsuccessful tasks require a formal justification and a corresponding adjustment in the project timeline, fostering professional accountability.
- *Final Documentation:* The term culminates in a comprehensive Project Report, which serves as a technical record of the design, implementation, and lessons learned.

C. Phase III: Public Communication and Professional Validation

The final assessment is a public senior showcase where teams present their results through professional posters and live functional demonstrations. This serves as an authentic assessment of student learning, requiring the interdisciplinary team to synthesize their specialized technical work and translate complex engineering decisions for a diverse audience of stakeholders.

- *Stakeholder Evaluation:* A panel of judges, including community members, faculty and industry representatives, evaluates the projects based on technical feasibility and innovation.
- *Visual Communication:* A professional poster was designed to summarize the project through concise text and relevant technical imagery Also; students are provided a dedicated stand and are required to utilize the space effectively to display their final physical prototype.
- *Oral Communication:* Students participate in a two-and-a-half-hour showcase where they must defend their technical decisions to various audiences.

3. Project Description

This project focuses on the development of a low-cost autonomous driving system adapted to a ride-on vehicle, emphasizing real-time obstacle avoidance without reliance on high-cost sensors or complex AI-models. The development followed a structured six stage lifecycle encompassing research, design, pre-integration, integration, calibration, and testing. In the context of autonomous navigation, real-time object avoidance is critical for safety and reliability, requiring the system to capture and process environmental data to determine collision-free paths through specialized algorithms. To guarantee accessibility and scalability, the system was developed under four primary technical constraints: utilizing a single camera as the sole input, avoiding both static and dynamic obstacles without human intervention, maintaining low-power computational efficiency, and adhering to a low-cost budget.

This solution addresses these limitations by leveraging visual looming algorithms as an AI-free alternative for real-time obstacle detection and avoidance. By analyzing the expansion rates of objects across successive image frames, the system determines proximity and time-to-collision without the need for depth sensing hardware or computationally heavy AI models that require extensive training. While smaller scale platforms like the JetBot have successfully demonstrated autonomous navigation, such systems typically utilize only two motors to change direction and speed simultaneously [10]. A unique contribution of this work is the adaptation of these algorithms to a system where two different motors control speed and steering independently, presenting significant technical challenges in interdisciplinary hardware and software integration.

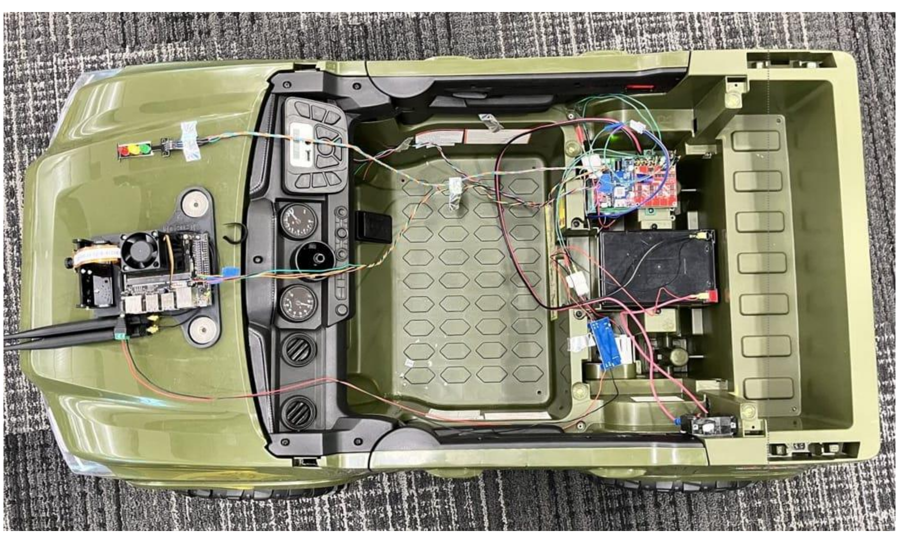

Figure 1. Completed constraint-driven autonomous ride-on vehicle prototype

A. Hardware Selection

To satisfy the project's primary technical constraints, the multidisciplinary team carefully selected specific hardware components before defining the system architecture.
For vision processing, the system utilizes an NVIDIA Jetson Nano. The Jetson Nano was selected because it perfectly balances the strict low-cost constraints of the project with the high computational power required to execute visual looming algorithms locally, while having extensive available literature surrounding the platform which provided a crucial self-directed learning resource (ABET 7) for the multidisciplinary team.

To bridge this high-level vision processing with the physical motor actuation, an ESP32 microcontroller was selected as the interface hardware. Since the Jetson Nano handles computationally heavy visual processing, the ESP32 is dedicated entirely to real-time I2C signal translation and Pulse Width Modulation (PWM) generation. Pedagogically, this intentional separation of hardware allowed the computer science students to focus on the Jetson Nano's vision environments while the computer and electrical engineering students managed the ESP32's embedded controls, facilitating parallel development and clear interdisciplinary boundaries.

Finally, the physical drive motors were pre-determined by the chassis of the ride-on car itself. This introduced an authentic, real-world constraint that forced the team to adapt their interface subsystem. While the motors remained in stock, the students had to exchange the original motor controllers to facilitate the necessary Pulse Width Modulation (PWM) and wireless connectivity.

B. System Design

The system architecture is organized into three distinct subsystems to facilitate modular control and the efficient processing of complex signal conversions. This division allows for specialized management of the technical challenges inherent in autonomous navigation, where the detection subsystem implements the visual looming algorithms, the interface subsystem manages signal translation, and the motion subsystem handles the physical hardware integration. Environmental data enters the system as a serial image stream from the camera and is processed to generate specific steering and velocity outputs as shown in Figure 1. Discrete signal conversions occur at each transition stage to ensure that the processing logic remains within the required operational ranges for the specific hardware components utilized. This structure confirms that an interdisciplinary approach is essential, as no single discipline could independently manage the transition from visual looming algorithms to physical motor actuation within the stated technical constraints.

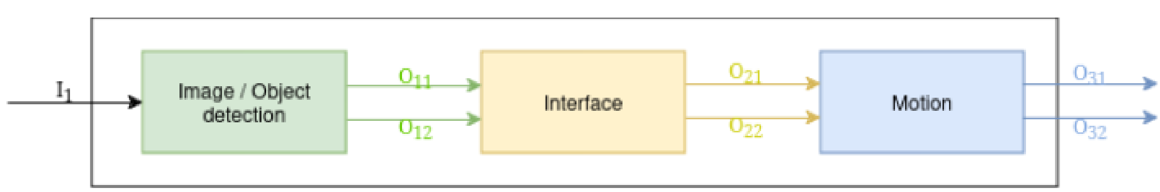

Figure 2. Autonomous Car Block Diagram

i. Image/Object Detection Subsystem

The detection subsystem serves as the primary processing unit for real-time visual data, enabling autonomous navigation and proactive obstacle avoidance through visual perception. A serial camera captures high frequency image frames which are processed by the Jetson Nano. Using visual looming algorithms [11], the processor analyzes successive frames to track object expansion rates and coordinate necessary avoidance maneuvers. This subsystem outputs specific steering values in a discrete integer range (typically 100 to 102) representing full left, centered, and full right orientations respectively. Concurrently, it generates velocity values ranging from 0 to 25, where 0 represents a braking signal, and 25 denotes the maximum speed limit. These parameters are then transmitted via I2C communication to the interface subsystem for final execution.

Figure 4 shows the flowchart for the obstacle avoidance algorithm. The process initiates with image capture, followed by pre-processing stages such as color segmentation, filtering, and contour detection to identify potential obstacles. The algorithm's logic is divided into two primary components:

- *Directional Logic:* Once an object is detected, the system calculates its centroid relative to six defined zones in the frame. If the centroid is in the outer zones (0 or 5), the vehicle stays centered; if the obstacle is detected on the left (zones 1-2), the system steers right, and if it is on the right (zones 3-4), it steers left.
- *Speed and Proximity Control:* The system manages velocity by calculating "looming," which is the rate of change in an object area over time. If the object's area is expanding ($L>0$), indicating it is approaching, the system reduces speed or brakes; if the area is shrinking ($L<0$), the system accelerates; if there is no change ($L=0$), it maintains a constant speed.

Upon completing these calculations, the steering and velocity commands are transmitted via I2C for immediate hardware adjustments, with the loop repeating continuously until the user terminates the process.

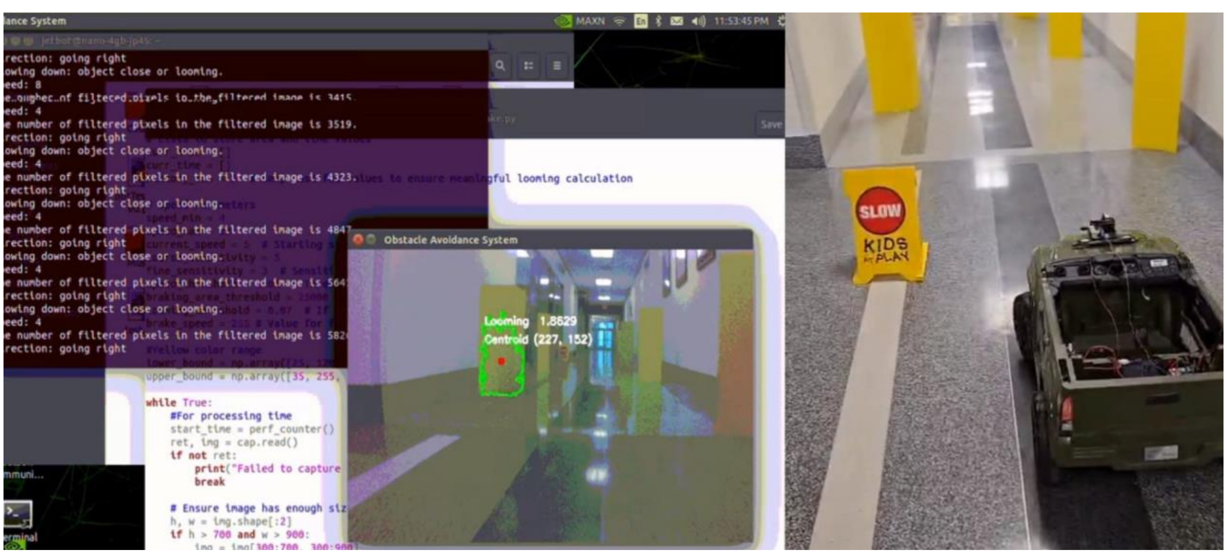

Figure 3. Screenshot of Visual Looming Algorithms Working

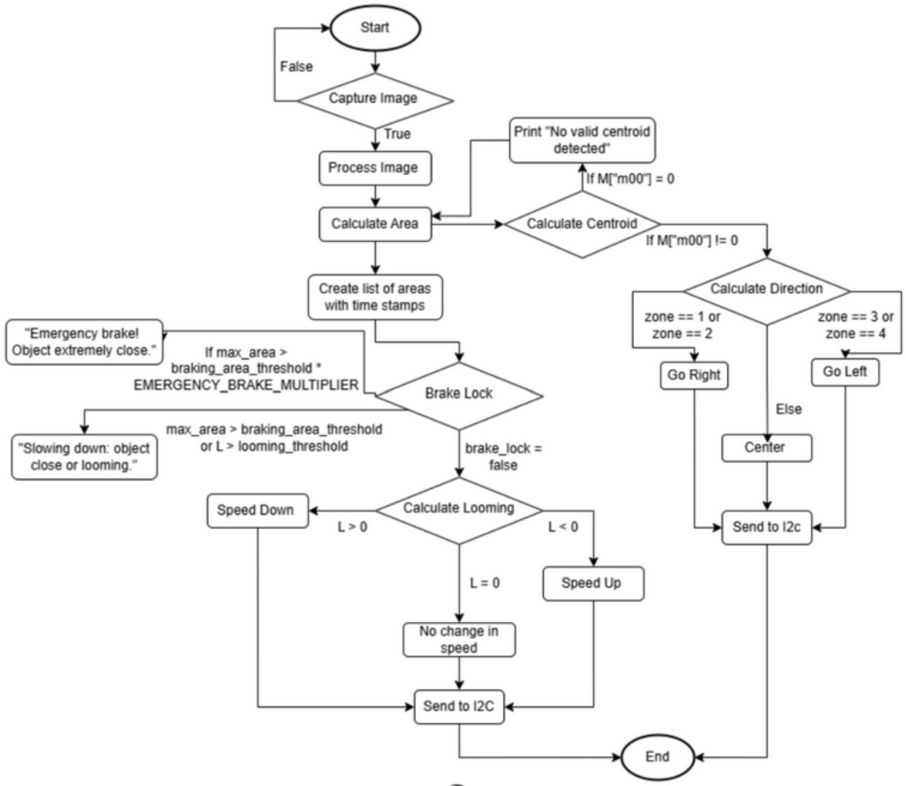

Figure 4. Flowchart of Avoidance Algorithm

ii. Interface Subsystem

The interface subsystem establishes a bridge between high-level vision processing and physical actuation, utilizing the ESP32 linked to the Jetson Nano through an I2C communication bus. Upon receiving the steering and speed inputs, the microcontroller processes the data and transmits corresponding commands to a motor driver capable of managing multiple independent motors simultaneously. The system utilizes Pulse Width Modulation (PWM) to regulate motor velocity, with dedicated input pins on the microcontroller determining the direction of rotation. Although the control signals are handled digitally by the microcontroller, the motor driver facilitates the conversion to the high-current analog signals necessary to actuate the drive systems. The resulting outputs directly interface with the motion subsystem to govern the car's physical trajectory.

iii. Motion Subsystem

The motion subsystem comprises the physical drive components and their respective feedback connections to the interface logic. Power is supplied by a central battery which provides an analog voltage to the motor controller for distribution throughout the drive system. The right and left wheel motors receive analog PWM signals to govern forward velocity, while the steering motor is actuated by a separate, dedicated PWM signal from the interface. Furthermore, a mechanical feedback loop is maintained via a sensor connected to the steering motor, which transmits positional data as an analog signal back to the interface subsystem. This continuous feedback enables the system to track steering movements and calibrate directional control in real-time during autonomous operation.

4. Assessment and Evaluation

A. Technical Performance Evaluation

The system was evaluated against a rigorous set of predetermined functional and safety requirements. Rather than exhaustively listing all subsystem micro-requirements, the project's success was ultimately defined by passing critical, high-level constraints:

- *Primary Functionality:* The system must drive autonomously using visual looming algorithms as the sole input, successfully detecting and altering its path to avoid obstacles without user intervention.
- *Critical Safety:* The system must include integrated fail-safe mechanisms, including an emergency stop available in both manual and autonomous modes, and an autonomous timeout function to handle unexpected logical failures.

To validate these requirements, the team performed a series of incremental tests to guarantee the autonomous system's reliability in real-world scenarios. These tests served as short-term milestones to ensure the system was ready for more complex environments, culminating in the advanced multiple-object avoidance test (see Table 1).

Table 1. Performance evaluation for Avoidance

Name	Level of avoidance	Description
Dummy Car Test	No avoidance	Test basic movements with everything connected but in manual mode.
Basic Level Test	Avoid stationary object	Test that the car can avoid at least one stationary object in autonomous mode.
Medium Level Test	Avoid moving object	Test that the car can avoid an object that is moving toward the car in autonomous mode.
Advanced Level Test	Avoid multiple moving objects	Reach a goal while avoiding multiple moving objects in autonomous mode.

B. ABET Outcomes Evaluation

The assessment of student performance was conducted through three distinct lenses: internal faculty-led grading, formal rubric-based analysis for programmatic accreditation, and external competitive validation via showcase awards.

i. Faculty-Directed Assessment

The faculty advisors provided a comprehensive evaluation throughout the two-term sequence, resulting in a final letter grade for the team. The students achieved an "A" grade in both terms, indicating that the project successfully met all internal course learning objectives and demonstrated mastery of the subject matter from an academic perspective.

ii. Rubric-Based Programmatic Assessment

To satisfy programmatic accreditation requirements, the team utilized the pragmatic assessment framework developed by Szatmary [6]. This tool was selected because it prioritizes student learning and provides clear compliance with ABET Student Outcomes (SO) 1-7 through the use of validated performance indicators. Each team member and the two project advisors utilized the Szatmary rubrics to rate the project on a scale of 1 (Beginning) to 4 (Exemplary). Table 2 summarizes the collective results with the evidence from the project, reflecting the team's ability to transition from conceptual design to a validated physical prototype.

iii. External Professional Recognition and Awards

The project's impact and technical execution were recognized through a series of prestigious awards during the senior showcase. This public forum involved evaluations from three distinct stakeholder groups: the general public, university faculty, and industry judges. The project successfully secured two of the three major honors available: people's choice award, and faculty choice award. Winning these awards provides a qualitative counterpoint to the quantitative data in the ABET rubrics, demonstrating that the team excelled in both "soft skills" like public engagement and "hard skills" like technical innovation.

Table 2. ABET Rubric Summary Score

Outcome	Score	Evidence
ABET 1: Problem Solving	4.0	Detailed description and formulation of an "AI-free" navigation problem, using visual looming models to solve for proximity and time-to-collision without depth sensors
ABET 2: Design	3.8	Execution of a six-stage lifecycle (research, design, pre-integration, integration, calibration, testing) to produce a low-cost solution under strict single-sensor constraints.
ABET 3: Communication	4.0	Development of a comprehensive technical Project Report, a professional poster summary, and a live functional demonstration at the senior showcase
ABET 4: Professional Responsibility	4.0	Systematic consideration of safety requirements (e.g., emergency stops, speed limits) and the impact of low-cost, accessible technology on scalability
ABET 5: Teamwork	3.8	Multidisciplinary team management involving CS, CE, and EE students utilizing weekly individual accountability reports and structured subsystem delegation.
ABET 6: Experimentation	4.0	Conducted a four-tiered testing protocol (Dummy, Basic, Medium, Advanced) to analyze and interpret real-time data from the visual looming sensor.
ABET 7: Self-directed Learning	4.0	Applied new knowledge in visual looming algorithms and I2C signal translation to solve the unique challenge of independent motor control for speed and steering

5. Discussions on Lessons Learned and Integration Challenges

The implementation of the solution proved technically demanding, revealing several complexities that were overlooked during the initial design phase due to limited familiarity with specific hardware-software interactions. These pivotal issues provided significant pedagogical lessons regarding system stability, control logic, and multidisciplinary coordination.

A. Connectivity and Power Stability

Wireless connectivity to the Jetson Nano presented early difficulties, as issues with remote desktop sharing and Wi-Fi packet transmission caused substantial delays in the camera feed. This latency hindered the team's ability to observe the real-time performance of the visual looming algorithm. The solution required implementing a dedicated, high-performance Wi-Fi networking card specifically for the Jetson Nano and limiting the local network to a maximum of three connected devices.

Maintaining stable power to the processor was a concurrent challenge. While initial testing with a direct 5V source was successful, integration with the ESP32 caused slight voltage drops. These drops triggered system warnings and eventually led to hardware shutdowns. Through rigorous measurement of current and voltage, the team determined that the Jetson Nano required an isolated, stable voltage supply. This was achieved by bypassing the shared power rail and connecting the processor directly to the battery via a dedicated buck converter.

B. Steering Adjustments and Calibration

Fine-tuning the steering mechanism was one of the most challenging integration tasks, as it required the seamless convergence of all three subsystems. The team modified the control algorithm several times to eliminate steering wheel "jittering" and correct directional logic. This process was heavily dependent on the calibration of potentiometer values, which required multiple iterations because sensor feedback changed relative to the system's required position. Furthermore, the physical alignment and engagement between the potentiometer and the steering motor required two complete hardware adaptations to ensure reliable function.

C. Image Processing and Environmental Complexity

Real-time image noise posed significant difficulties for vision computing, particularly when the system encountered objects other than the intended target. The team evaluated various avenues to handle these errors, ultimately implementing yellow color segmentation. Yellow was selected due to its clear HSV range and distinguishability under varied lighting conditions. While successful for a single target, time constraints prevented the further enhancement of this logic for multiple simultaneous targets or the implementation of alternative methods such as optical flow.

D. Interdisciplinary Interconnectivity and Communication

Because the system was divided into three subsystems developed independently, significant integration issues arose during the final interconnection phase. Troubleshooting the connectivity between these parts required six weeks of intensive testing, reinforcing the need to safeguard sufficient time for full-system validation in complex projects.

As an interdisciplinary team, maintaining effective communication, detailed meeting notes, and regular advisor guidance were vital to resolving information conflicts. Ultimately, the project highlighted that every component, and the discipline responsible for it, is equally critical to the success of the integrated whole. Maintaining this holistic perspective is essential for avoiding redundant work and guaranteeing project success.

6. Best Practices and Reproducibility

Based on the implementation of the multidisciplinary autonomous vehicle project, the following best practices are proposed for faculty seeking to reproduce similar constraint-driven capstone experiences.

- *Constraint- Driven Technical Scoping:* Strict technical limitations, such as the use of a single-camera sensor and a low-cost budget, encourage students to prioritize computational efficiency and realistic goal setting. By limiting available resources, the project forces a transition from "brute-force" hardware solutions to deeper algorithmic exploration, exercising the critical thinking and problem-solving abilities required in professional practice. This approach successfully closes the gap between academia and real-world engineering where social, cultural, and economic constraints must be addressed [12].
- *Staged Lifecycle and Phase-Gate Integration:* The adoption of a structured, six-stage lifecycle (Research, Design, Pre-integration, Integration, Calibration, and Testing) provides a clear roadmap for multidisciplinary teams managing hardware-software convergence. Implementing a "phase-gate" process with incremental milestones, such as formal class demonstrations, allows teams to focus on immediate tasks rather than becoming overwhelmed by the final deliverable. These gates guarantee that technical decisions are defended and validated before proceeding, mirroring the "Go/No-Go" decision-making found in industrial product development.
- *Individual Accountability:* For effective multidisciplinary collaboration, each team member must be assigned specific weekly tasks that contribute to a unified project goal. This structure fosters a culture of professional accountability, where individual contributions are documented, and justifications are required for unmet objectives. Such granularity in task management facilitates cohesive communication and prevents the delays commonly associated with complex systems integration.
- *Structural and Administrative Synchronization:* The institution needs to provide space, tools, and faculty support to be able to host a creative environment where the students can be successful.

7. Conclusion

The successful implementation of this vision-based system demonstrates that a low-cost, AI-free approach to autonomous navigation is technically viable and pedagogically rich. By balancing strict technical constraints with a multidisciplinary management structure and the Szatmary [6] assessment framework, the project validated that undergraduate teams can master complex systems integration while meeting all seven ABET Student Outcomes. The recognition of this work through public and faculty awards further validates the multidisciplinary case study as a reproducible model for engineering education.

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References

[1] S. Jahanian and J. M. Matthews, "Multidisciplinary Project: A Tool for Learning the Subject," *Journal of Engineering Education*, vol. 88, no. 2, pp. 153–158, Apr. 1999.

[2] L. Zheng, D. Hu, and B. K. Jesiek, "A Systematic Review of Multidisciplinary Engineering Education: Accredited Programs, Educational Approaches, and Capstone Design," presented at the *2021 ASEE Annual Conference*, Virtual Meeting, July 26–29, 2021, Paper 32751.

[3] ABET, "Criteria for Accrediting Engineering Programs, 2025 – 2026," *ABET*, 2025. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2025-2026/. [Accessed: Jan. 21, 2026].

[4] N. Hotaling, B. B. Fasse, L. F. Bost, C. D. Hermann, and C. R. Forest, "A Quantitative Analysis of the Effects of a Multidisciplinary Engineering Capstone Design Course," *Journal of Engineering Education*, vol. 101, no. 4, pp. 630–656, Oct. 2012.

[5] A. R. Murphy *et al.*, "A New Approach to Capstone Design through Multidisciplinary Collaboration at Florida Polytechnic University," presented at the *2025 ASEE Annual Conference & Exposition*, Montréal, QC, Canada, June 22–25, 2025, Paper 47721.

[6] A. C. Szatmary, "Tools for Comprehensive Assessment of the 7 ABET Student Outcomes in Mechanical Engineering, with Application to Capstone Design," presented at the *2023 ASEE Annual Conference & Exposition*, Baltimore, MD, USA, June 25–28, 2023, Paper 39426.

[7] K. Meah, D. J. Hake II, and S. D. Wilkerson, "A Multidisciplinary Capstone Design Project to Satisfy ABET Student Outcomes," *Education Research International*, vol. 2020, Article ID 9563782, June 2020.

[8] A. Qattawi, A. Alafaghani, M. A. Ablat, and M. S. Jaman, "A Multidisciplinary Engineering Capstone Design Course: A Case Study for Design-Based Approach," Int. J. Mech. Eng. Educ., vol. 49, no. 1, pp. 1–16, Oct. 2019, doi: 10.1177/0306419019882622.

[9] D. Wilde and J. Archibald, "The Robot Racer Capstone Project," presented at the *2009 ASEE Annual Conference & Exposition*, Austin, TX, USA, June 14–17, 2009, Paper AC 2009-608.

[10] J. D. Yepes Arango, "Collision free navigation in 3D unstructured environments using visual looming," Ph.D. dissertation, Dept. Elect. Eng. Comput. Sci., Florida Atlantic Univ., Boca Raton, FL, 2023.

[11] D. Raviv, "A Quantitative Approach to Looming," National Institute of Standards and Technology (NIST), Gaithersburg, MD, NIST Interagency/Internal Report (NISTIR) 4808, 1992. Available: https://nvlpubs.nist.gov/nistpubs/Legacy/IR/nistir4808.pdf

[12] N. A. Baine, "Evaluating ABET Student Outcome (2) in a Multidisciplinary Capstone Project Sequence," presented at the *2022 ASEE Annual Conference & Exposition*, Minneapolis, MN, USA, June 26–29, 2022, Paper 36997.