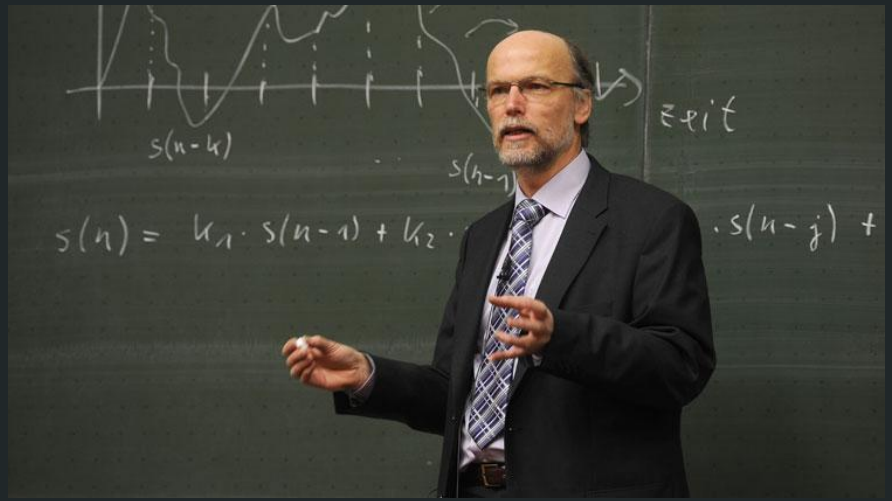
InFrame

Ike Kilinc, Diego Martinez, Thor Mercier

Application Area

InFrame

Lecture Filming



Action Shots

Use Cases | Goals | Reqs & Sols | Interactions | Verification

Primary Subsystems & Core Goals within Each

Computer Vision

- ➔ Detection
- ➔ Tracking
- ➔ Handling occlusions where possible

Hardware

- ➔ Camera positioning
- ➔ Frame recording
- ➔ CV hosting compute

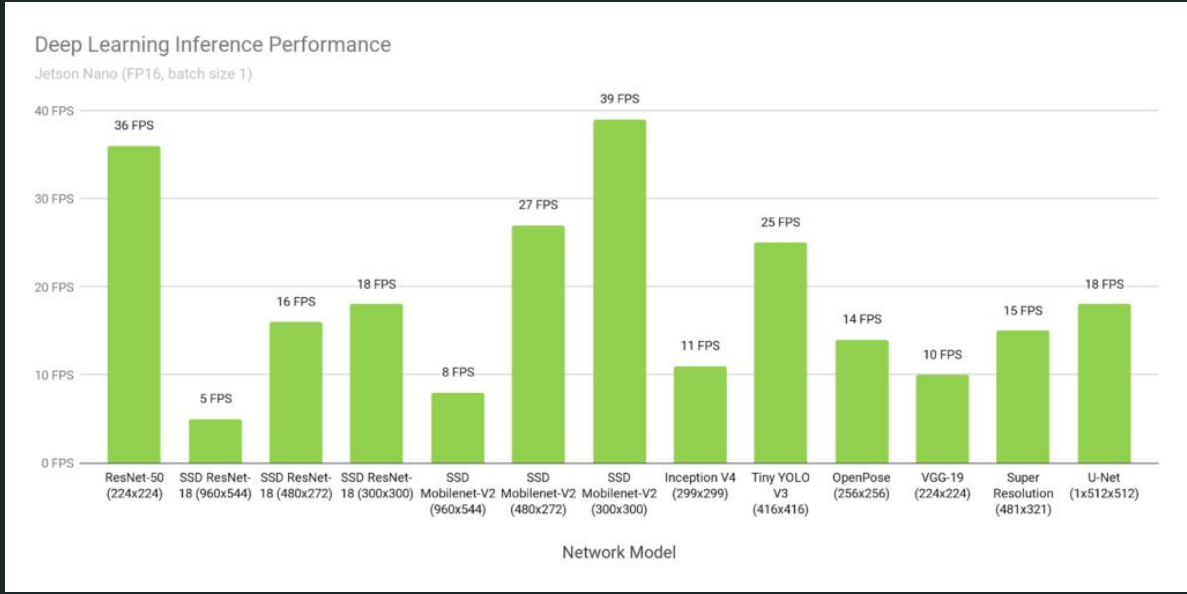
System Control

- ➔ Controlling the full stack
- ➔ Managing multithreaded operations
- ➔ Bridge user interaction to functionality

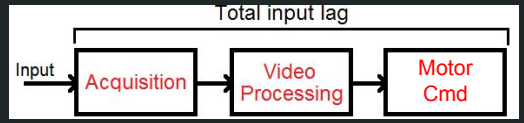
Requirements & Solutions: Computer Vision

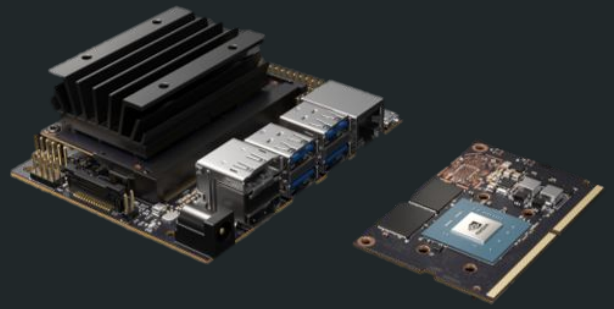
Goals	Requirements	Solutions
Object detection	>80% accuracy in frames with our use cases	Pre-trained models that include our use-cases in their classes
Tracking detected object	With no occlusions and no lighting changes, never lose target	Lucas-Kanade tracking with DL optimizations
Detect slow walking human (e.g. lecturer)	Use an object detection model with people in its classes	MobileNetV2 trained on COCO dataset, which includes 'person' class
Detect fast moving entity (e.g. skateboarder, soccer ball)	Use a model with these items in its classes	MobileNetV2 trained on COCO dataset, which includes bicycles, cars, frisbees, skateboards and sports balls
Detect fast falling entity (e.g. diver, falling rock climber)	High FPS camera so that movement between frames minimal	Picam with 1080p60 and 720p180

Requirements & Solutions: Computer Vision



≤ 60 ms



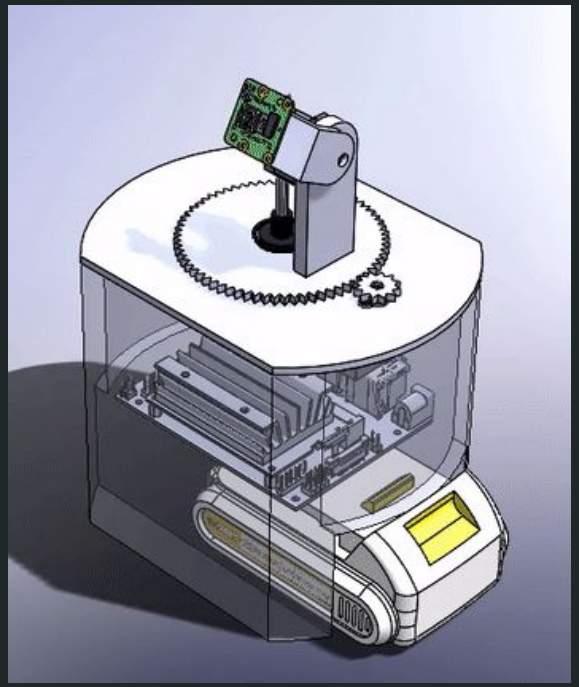


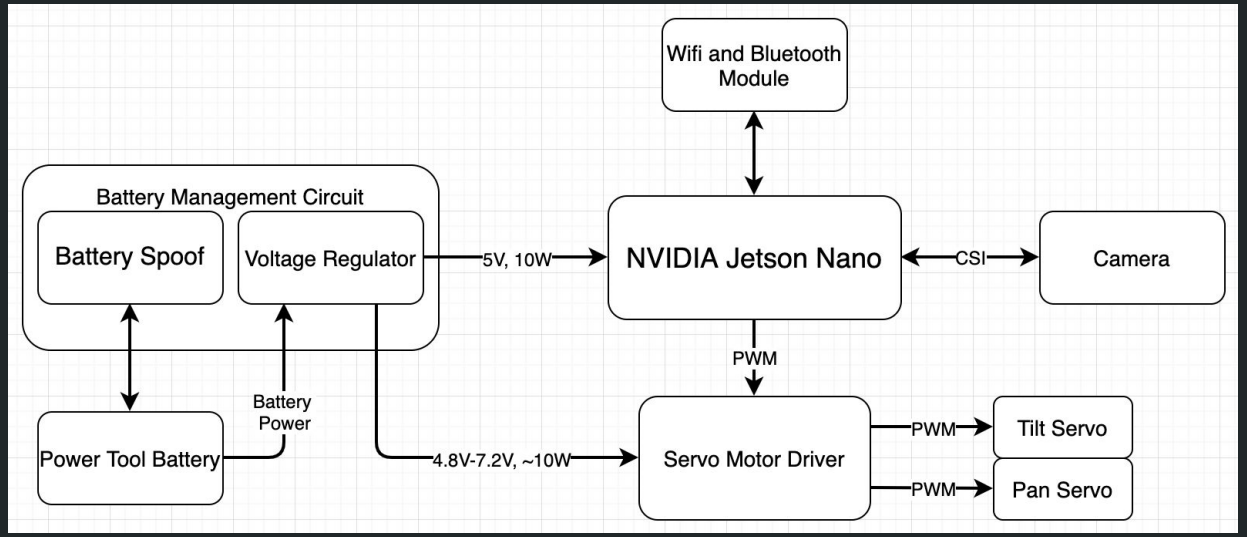
Use Cases | Goals | Reqs & Sols | Interactions | Verification

Requirements & Solutions: Hardware

Goals	Requirements	Solutions
Freedom to move / be tracked anywhere in space	Continuous 360(deg) RoM / rotation	Slip Ring / quick turnaround
Move to track fast horizontal motion	Pan servo move at 36.87 (deg/s) @ full camera load	Continuous rotation servo motor
Move to track medium speed vertical motion	Tilt servo move at 38.66 (deg/s) @ full camera load	Maxmoral 2pcs MG90S 9g Metal Gear Pro Servo
Smooth motion horizontally/vertically	Motion jerk has little to no -ve impact on video quality	Big box (boundary), little box (size determined by BB update freq) (user defined)
Stable camera frame (no jitter/shake)	(T_stable - T_moveEnd) < 30ms (1 frame)	TBD
Tripod mountable	Base built with standard tripod receiver	Screw receiver with standard 1/4" - 20 thread/inch
Independent of electrical socket	Battery life would last the length of a trip (e.g. hike)	Removable batteries with 3.5 hr capacity
Backpack storable	Size < 26.5"h x 17.5"w x 6.5"d	S/I
Limit system temp at max load	Max Internal Temp < 60 °C	Side ventilation, etc.

Requirements & Solutions: Hardware



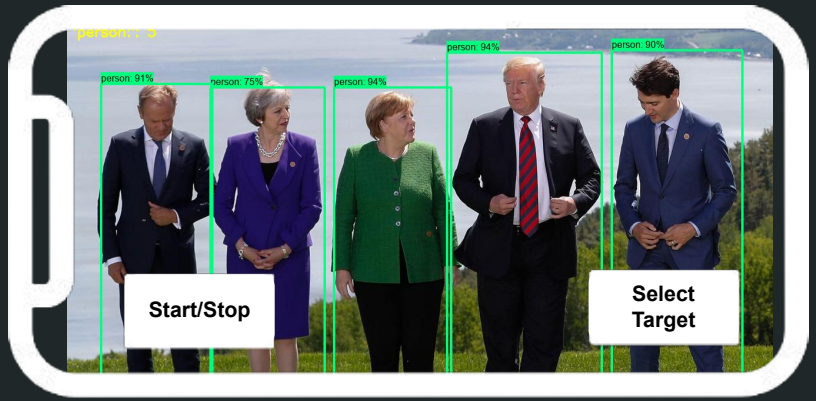


Requirements & Solutions: System Control

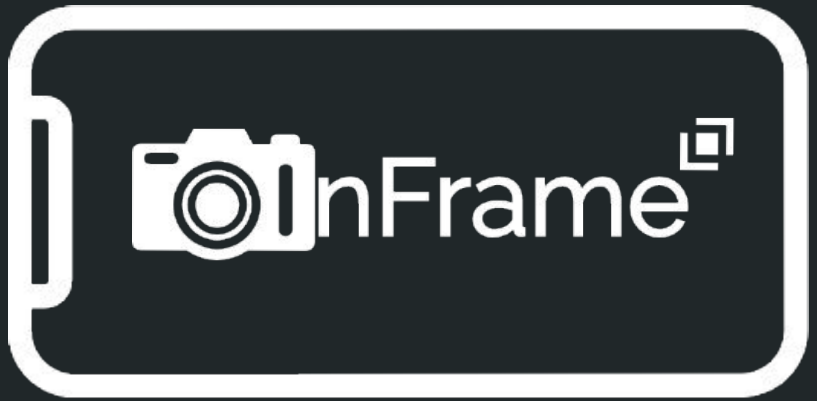
Goals	Requirements	Solutions
Intuitively interface with camera control and its feed	Screen and User Input	iOS interface for control
Ability to control while mobile	Wireless interface	Bluetooth capabilities of iOS framework
Video storage without immediate uplink	On-board backup of video content	Store video locally
Easy to select tracking subject	Polling time for curr frame < 2s	S/I
Easy to set up device & phone	Bluetooth pair time < 20 seconds	S/I
Intuitive mode selection	Post pair reach destination time < 2 clicks	S/I

Requirements & Solutions: System Control

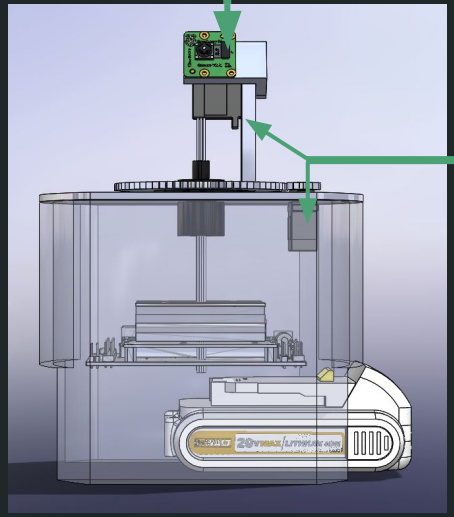
CORE

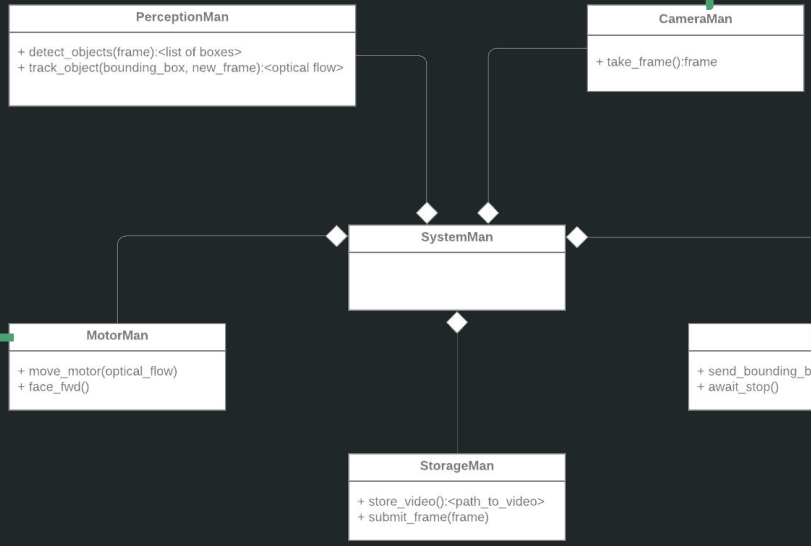


On Boot



Overarching System Interaction Diagram





Use Cases | Goals | Reqs & Sols | **Interactions** | Verification

Parts for Purchase -- Feedback!

Part	Name	Cost	Addit. Specs	Link
Tilt Servo	Maxmoral 2pcs MG90S 9g Metal Gear Pro Servo	$9.99	2.0KG/cm, 0.11s/60 Degree	Amazon
Pan Servo	Metal Gear Micro Servo / Continuous Rotation	$16.99	Stall Torque - 1.8 kg / cm (4.8V)	Amazon
Camera	Raspberry Pi Camera Module V2 - 8MP, 1080p	$28.20	1080P60, 720P180	Amazon
Battery	Waitley M18 18V 6.0Ah Replacement Battery	$42.98	6.0Ah	Amazon
Central Compute	Jetson Nano Developer Kit	$99		NVIDIA
Battery Adapter	Milwaukee 49-24-2371 M18 Power Source	~$33		Amazon
Slip-ring	TBD	TBD		TBD

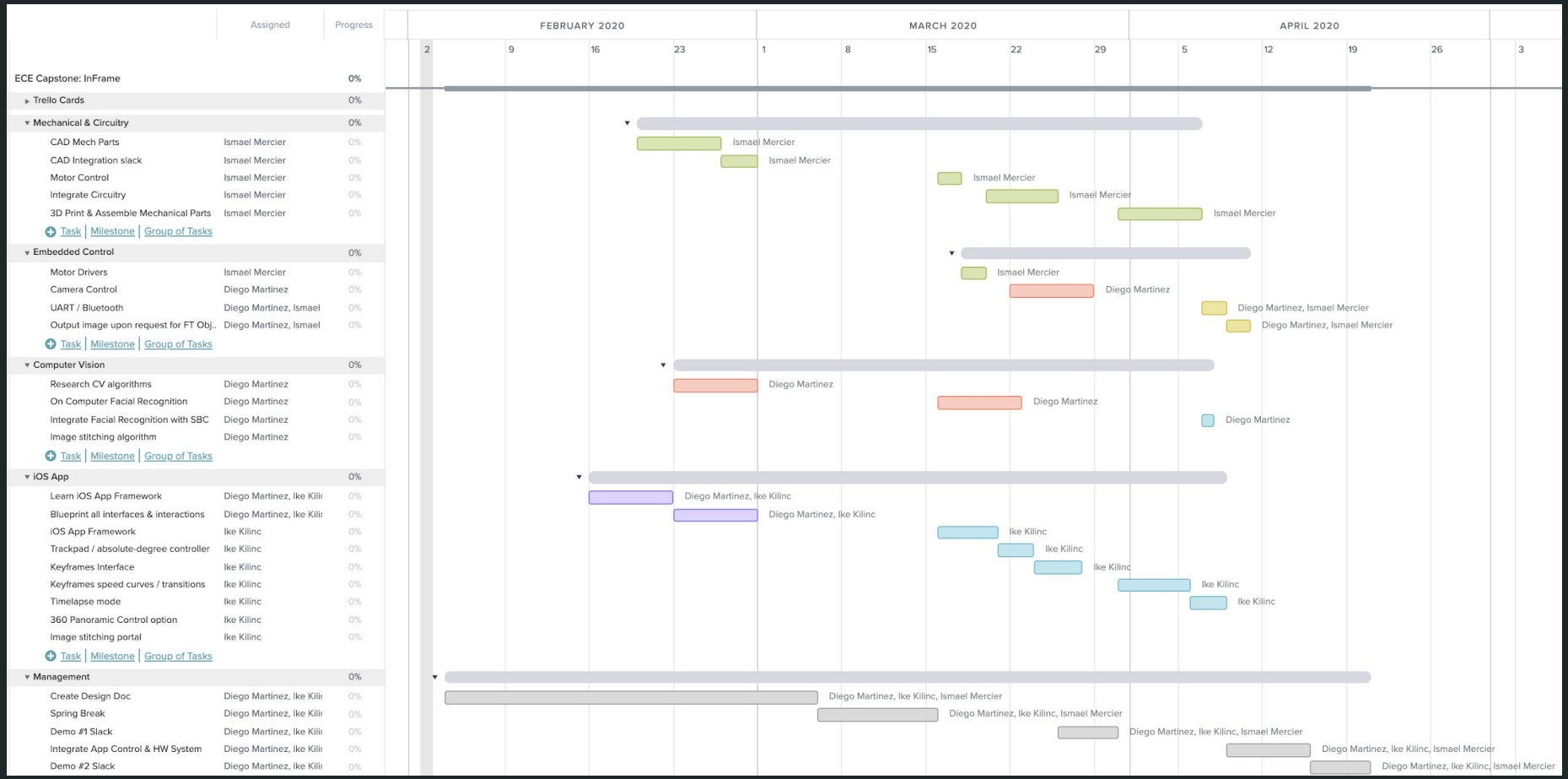
Testing & Verification: Full System

Lecture Filming

- ➔ Film Tom Mitchell teaching 10-701 lecture
- ➔ Success: Identifies teacher as potential target
- ➔ Success: Does not lose target throughout 1.5 long lecture (e.g. when standing student occludes frame)
- ➔ Success: Battery lasts 3 hour lecture duration
- ➔ Success: Does not switch targets from teacher to student viewer at arbitrary time

Action Shot: 3m Diver

- ➔ Film CMU divers during practice
- ➔ Success: Can identify diver as potential target
- ➔ Success: Follows target at top of motion (slowest)
- ➔ Success: Follows target at bottom of motion (fastest)
- ➔ Success: Camera stays in place once target is lost as they enter the water



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