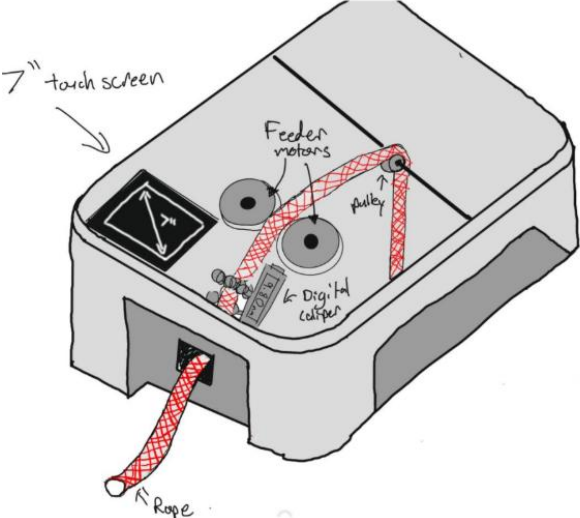


CYSF 2026 Logbook – Ideation Phase (July 31, 2025 – October 31, 2025)

<p>Ideation – Idea origin (2025-07-31)</p>	<p>Inspiration</p>	<ul style="list-style-type: none"> • Learned how to inspect a climbing (dynamic) rope in an indoor lead climbing lesson and found the manual process strenuous and time consuming • Felt that the current inspection process which involves both a visual and tactile check could potentially endanger those who are inexperienced as it is easy to miss a damaged section of rope or make a poor choice to continue climbing on a damaged rope • Given my last year’s CYSF experience with building Machine Learning Neural Networks, I wondered if AI could also be used for rope inspection, which formulated this initial question: <ul style="list-style-type: none"> ○ How might machine learning be used to inspect climbing ropes for damage?
<p>Ideation – Week 1 (2025-08-10 – 2025-08-16)</p>	<p>Research</p>	<ul style="list-style-type: none"> • Browsed climbing rope manufacturers’ websites to build on my existing knowledge of dynamic kernmantle rope diameters and types • Conducted a literature review on academic research articles on climbing ropes by searching in Google Scholar <p>Articles included (these are documented in the list of References for Background Research):</p> <ul style="list-style-type: none"> ○ “Proper care maintenance and inspection of climbing ropes to reduce degradation and help determine when to retire them” ○ “Critical factors affecting the strength of climbing ropes; A study of wear, fatigue loading and temperature” ○ “Design and Performance of Ropes for Climbing and Sailing” <ul style="list-style-type: none"> • From the literature review, I recognized the uniqueness and inspection challenges specific to kernmantle ropes given their construction

		<ul style="list-style-type: none"> • Learned about chemicals that weaken the synthetic materials in the rope and signs of their contamination • Discovered that some third-party contractors offer formal rope inspection as a service to the oil & gas industry. This prompted me to read more about industrial usage of ropes. • Learned about the existing digital PPE management and record keeping solutions (e.g. Petzl's ePPEcentre app and Scannable) available on the market <p>Links:</p> <ul style="list-style-type: none"> ○ https://www.petzl.com/brand/s/eppecentre?language=en_US ○ https://www.scannable.io/
	<p>Technology Options</p>	<ul style="list-style-type: none"> • Considered the digital and mechanical process flow to inspect a climbing rope • Started reading about cameras that will capture real-time rope images and feed to a Machine Learning model for damage detection • Explored the use of IP streaming cameras such as the Espressif ESP32-CAM for its ability to be programmed with the Arduino IDE, run off 5v of power, and output up to 30 frames per second <p>Video:</p> <ul style="list-style-type: none"> ○ Use a ESP32-CAM Module to Stream HD Video Over Local Network https://www.youtube.com/watch?v=g1J_7lx5QEU <ul style="list-style-type: none"> • Explored different machine learning frameworks used to classify images and learned about Convolutional Neural Networks (CNN) which uses convolution to improve the image classification accuracy <p>Videos:</p> <ul style="list-style-type: none"> ○ Why convolution networks work so well (on images) https://www.youtube.com/watch?v=uE6ToVhjYQE&t=205s

		<ul style="list-style-type: none"> ○ But what is a convolution? https://www.youtube.com/watch?v=KuXjwB4LzSA&t=2s ● Explored potential design concepts which would utilize a 5 kg load cells and/or digital calipers to inspect the hidden core strands <p>Videos:</p> <ul style="list-style-type: none"> ○ Caliper and Arduino i2c - measure 3D filament https://www.youtube.com/watch?v=tTV52DihPTc ○ HX711 Load Cell - How to Use with Arduino https://www.youtube.com/watch?v=pyeeyMsiNn0&t=32s
	<p>Conceptual design</p>	<ul style="list-style-type: none"> ● Sketched up a 4-camera system for a visual module to scan the rope's outer sheath for damage, taking inspiration from a YouTube video showcasing UVEye's car inspection software <p>Video: Amazon unveils new AI-powered technology to inspect delivery vans https://www.youtube.com/watch?v=DEElv6Ak7fw&t=1s</p> <p>Preliminary conceptual design:</p> 

<p>Ideation – Week 2 (2025-08-17 – 2025-08-23)</p>	<p>Research</p>	<ul style="list-style-type: none"> Spoke with Ms. Maria Mitrea of Calgary Climbing Centre’s Chinook location and learned that the climbing ropes used in the gym are replaced long before they begin to show visible damage as they first lose their shape and have poor handling capabilities Found the official Petzl rope inspection checklist in a blog post by “Weigh my Rack” which I read to learn about the different signs of rope wear and damage to look out for when inspecting your rope <p>Links:</p> <ul style="list-style-type: none"> Weigh my Rack Blog: https://blog.weighmyrack.com/when-to-retire-how-to-inspect-climbing-rope/#:~:text=Check%20your%20Rope%20for%2

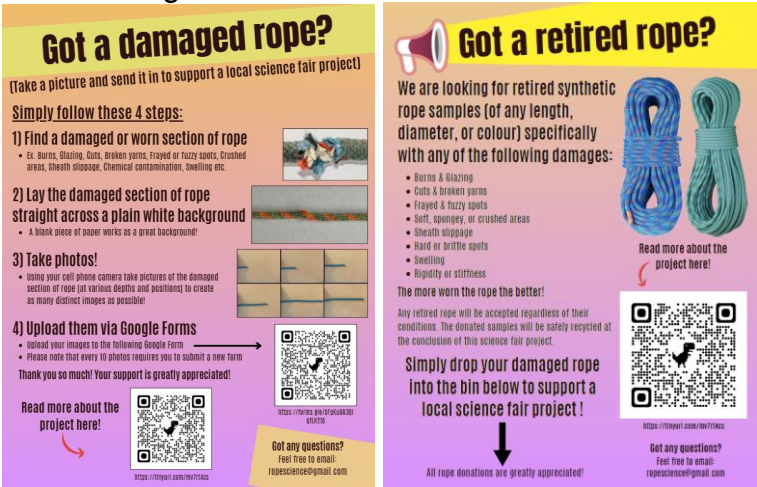
		<p>0Damage&text=While%20you're%20moving%20the,is%20damage%20to%20the%20rope</p> <ul style="list-style-type: none"> ○ Petzl rope inspection checklist: https://www.petzl.com/sfc/servlet.shepherd/version/download/068Tx000003grXhIAI ○ Petzl rope inspection procedure: https://www.petzl.com.au/wp-content/uploads/2018/08/ropes-SPORT-procedure-EN.pdf <ul style="list-style-type: none"> ● Watched 7 YouTube videos from a channel named “<i>Hard is Easy</i>” to learn about the construction, testing, wear, and chemical properties of climbing ropes <p>Videos:</p> <ul style="list-style-type: none"> ○ Every Test Climbing Ropes Have to Pass https://www.youtube.com/watch?v=JnNA4mLqwtQ ○ Cut Resistance of Climbing Ropes Analysed https://www.youtube.com/watch?v=dpmUFQhMdbI ○ Surprising Effect of Dirt on Climbing Ropes https://www.youtube.com/watch?v=quB-KEsqJNU ○ Are Wet Ropes Dangerous for Climbers? Textile Science Explained https://www.youtube.com/watch?v=5gyt46i4c4E ○ The Last Unsolved Problem of Climbing Ropes https://www.youtube.com/watch?v=x3PMT6K0Gg ○ Complete Guide to Climbing Ropes - How many falls they Hold? Why they Twist? Ep.5 https://www.youtube.com/watch?v=ncUGR2JbefY ○ Lab Test - How Soft is too Soft? How Fuzzy is too Fuzzy? https://www.youtube.com/watch?v=UWy91q77zpW <ul style="list-style-type: none"> ● I also watched 2 videos which were produced with Martin Schlemmer, head of rope development at Edelrid. In these videos, he discusses the different materials and constructions of ropes and their applications <p>Videos:</p> <ul style="list-style-type: none"> ○ Talking Rope Science with Martin Schlemmer - Inside EDELRID
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	<p>Project Scope</p>	<ul style="list-style-type: none"> ● I then looked up other synthetic rope construction types (e.g. hollow braid, double-braid, etc.) and learned about their differences from kernmantle ropes https://www.maximropes.com/rope-infos/ ● Decided to focus on kernmantle ropes given (a) their core/sheath structure makes it difficult to inspect, and (b) they are the most common rope type for all types of climbing
	<p>Technology Options</p>	<ul style="list-style-type: none"> ● Found a 7-inch touchscreen and decided it would serve as a great user interface tool like the screen of a printer while only requiring a USB-C and a HDMI connection to the host computer https://www.pishop.ca/product/7inch-hdmi-lcd-h-display-with-case-1024x600-ips/ ● Found a higher quality IP camera alternative to the ESP32-CAM called the Realtek AMB82-Mini IoT AI Camera https://www.youtube.com/watch?v=vl6GZMLfGQk&t=1s ● Learned that IP cameras such as the ESP32-CAM and the AMB82-Mini require an internet connection to the host microcomputer either via Wi-Fi or an access point ● Not wanting the IP cameras to be manually tied to a singular internet router, I explored the option of setting up an access point and learned that connecting IP cameras to a host computer set up as an access point would require either an ethernet cable or additional Wi-Fi antenna ● Wanting to avoid these connectivity workarounds that come with IP cameras, I decided to explore other solutions that would transfer video via wired means

<p>Ideation – Week 3 (2025-08-24 – 2025-08-30)</p>	<p>Research</p>	<ul style="list-style-type: none"> • Started looking into some well-known work-at-height jobs that require the use of ropes such as window cleaning and tree care • Searched online what types of companies / industries use kernmantle ropes and discovered some local rope access companies that offer training and/or inspection services, and found that they are member companies of some international trade associations • Read about the global rope access trade associations (IRATA and SPRAT) and their code of safe practices Links: https://irata.org/downloads/2055 https://sprat.org/publications/ • Definition of rope access and where it is used worldwide across multiple industries https://irata.org/page/what-is-rope-access • Further investigated the industrial applications for ropes (mainly for inspections, maintenance, and construction), including the major industries in Alberta such as Oil & Gas, Mining, and Building infrastructure • Learned that there are three types of inspections for industrial rope usage according to IRATA (section 2.10.1.3 on page 44) and SPRAT (equipment inspection checklist): <ul style="list-style-type: none"> ○ Pre-use check ○ Interim inspection ○ Detailed inspection / certification record at regular intervals per manufacturer’s guidelines (e.g. Petzl rope inspection checklist): https://www.petzl.com/sfc/servlet.shepherd/version/download/068Tx000003grXhIAI • Links: https://irata.org/downloads/2055 https://sprat.org/publications/
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		<p>https://www.pacificropes.com/blog/rope-access-equipment-inspection</p>
	<p>Technology Options</p>	<ul style="list-style-type: none"> • Explored the option of using a Raspberry Pi 5 as the main microcomputer board that would run the machine learning model https://www.raspberrypi.com/products/raspberry-pi-5/ • Learned about the use of additional Neural Processing Units (NPU) such as the Raspberry Pi AI HAT that would be needed to supply enough processing power for image classification tasks • Read about the process of training machine learning models on the Raspberry Pi boards and running them on the Raspberry Pi AI HAT https://www.raspberrypi.com/products/ai-hat/ Video: Raspberry PI AI HAT! Compiling your Custom Object Detection Model! https://www.youtube.com/watch?v=Dm37x7sOblc • Researched motor driver boards and learned about the 3 types of motors (DC motors, Stepper motors, and Servo motors) and their applications https://learn.adafruit.com/adafruit-motor-selection-guide • Selected stepper motors as they have high holding torque and precise movement control in comparison to DC motors • Found the Adafruit Motor Shield v2 and learned about its ability to stack on top of other shields using I2C communication and run off of any Arduino board confirming it is feasible to use an Arduino UNO R4 Wi-Fi board for its Bluetooth capabilities https://www.adafruit.com/product/1438 • Decided to use 2 adjustable 12-volt 5-amp Adafruit desktop power supply's at 12v and 5v with 4-way splitters to power both the motor shields and the Arduino boards • Learned about time-of-flight distance sensors (ToF) which emit a Lazer beam making them precise

		<ul style="list-style-type: none"> Recognized that I could use a ToF sensor to accurately measure the length of the rope as it is pulled through by the motors
<p>Ideation – Week 4 (2025-08-31 – 2025-09-06)</p>	<p>Research</p>	<ul style="list-style-type: none"> Realized that kernmantle ropes designed for professional (vs. sport) use are widely chosen as safety / fall protection ropes used across many different industries – but there is no documentation on how these choices of what ropes to use (types / lengths / diameters) are made My mom introduced me to the concept of informational interviews and suggested I reach out to professionals to learn about their day-to-day use of kernmantle rope in various work-at-height fields. https://www.linkedin.com/pulse/how-ask-make-most-informational-interview-jenny-foss I agreed with her suggestion as I remembered reading the Stanford design school (d.school) series of books years ago and their approach to human-centred design
	<p>Technology Options</p>	<ul style="list-style-type: none"> Read about the Nvidia Jetson Orin Nano Super Dev Kit and learned about its rapid processing speed and GPU acceleration technology https://www.nvidia.com/en-us/autonomous-machines/embedded-systems/jetson-orin/nano-super-developer-kit/ Learned that the Nvidia Jetson Orin Nano Super Dev Kit can deliver up to 67 TOPS, which offers plenty of processing power for running image classification or machine learning tasks Researched enclosures made of non-combustible materials and settled on plastic over metal and glass due to its non-conductive, lightweight, and durable properties Chose to go with IKEA SAMLA plastic boxes over building a custom enclosure out of polycarbonate or

		<p>acrylic due to the large size, structural rigidity, and ease of replacement</p>
<p>Ideation – Week 5 (2025-09-07 – 2025-09-13)</p>	<p>Users’ Needs</p>	<ul style="list-style-type: none"> I decided to first contact a member of the rock-climbing industry to gain insight into a field that I am more familiar with before reaching out to other professions
	<p>Project scope</p>	<ul style="list-style-type: none"> Created 2 posters to ask the climbing community for samples to train the model on (1 poster requesting for damaged rope samples and the other asking for images of their damaged ropes via a Google Form) <p>Poster designs:</p>  <ul style="list-style-type: none"> Began drafting a Project Brief document in which I refined my project’s guiding question: “How might cameras and machine learning be utilized, along with current inspection techniques and procedures, to inspect and monitor the condition of kernmantle climbing ropes?”
	<p>Technology Options</p>	<ul style="list-style-type: none"> Selected the Jetson Orin Nano Super Dev Kit over the Raspberry Pi 5 + 26 TOPS AI HAT given: <ul style="list-style-type: none"> The Jetson Orin Nano Super Dev Kit can deliver up to 67 TOPS which is more than double than the Raspberry Pi 5 + 26 TOPS AI HAT and can natively run ML models without needing to convert the file to ONNX format and then run it out of a docker container

		<ul style="list-style-type: none"> • Researched potential wired camera systems and learned about the differences between Camera Serial Interface (CSI) and USB cameras https://www.e-consystems.com/blog/camera/technology/mipi-camera-vs-usb-camera-a-detailed-comparison/ • Learned about USB port bandwidth and how it affects the number of USB devices that can be attached • Decided that I would use a 6-slot power strip as it can deliver up to 1800 watts of power from a standard household breaker which is considerably less than the combined total energy consumption of the following devices: <ul style="list-style-type: none"> ○ Jetson Orin Nano Super Dev Kit: 25 watts (in super mode) ○ Raspberry Pi 5 8GB: 45 watts ○ 2 x Adafruit 12-volt 5-amp power supply: 120 watts
<p>Ideation – Week 6 (2025-09-14 – 2025-09-20)</p>	<p>Project scope</p>	<ul style="list-style-type: none"> • Finalized and published my Project Brief online in the form of a Google Document that could be accessed from a QR code on the posters I made the previous week • Prepared a list of questions to ask at the informational interview (printed copies of items discussed are filed in my project binder)
	<p>Users' Needs</p>	<ul style="list-style-type: none"> • Completed informational interview #1 <ul style="list-style-type: none"> ○ Name: Simon Villeneuve ○ Organization: Calgary Climbing Centre (CCC) ○ Met at: CCC, Rocky Mountain location (Note: A meeting log of all informational interviews is attached to the condensed logbook) • Obtained permission to have the posters put up at CCC Rocky Mountain requesting for rope samples • Read the “rope” related sections of the Alberta Occupational and Health Safety (OHS) Code after it was mentioned in informational interview #1 <ul style="list-style-type: none"> ○ Part 5 - Confined Spaces

		<ul style="list-style-type: none"> ○ Part 9 - Fall Protection ○ Part 39 - Tree Care ○ Part 41 - Rope Access (which covers the safety standards required for dynamic and low-stretch ropes, e.g. EN, UIAA, NFPA) <p>https://search-ohs-laws.alberta.ca/legislation/occupational-health-and-safety-code/</p> <ul style="list-style-type: none"> ● Compiled a list of organizations / contacts by industries with whom I would like to request for information interviews, e.g. professionals in rope access training/certification, oil & gas, mining/confined space, construction, building/window services, wind energy, arboriculture, mountaineering, technical rescue, caving
	Technology Options	<ul style="list-style-type: none"> ● Continued to research camera solutions and came across the Arducam Quad-Camera array which could connect 4 cameras to a single CSI slot ● Learned that these 4 Sony IMX-219 cameras are compatible with the Nvidia Jetson Orin Nano Super Dev Kit and can provide up to 30 FPS each
Ideation – Week 7 (2025-09-21 – 2025-09-27)	Users’ Needs	<ul style="list-style-type: none"> ● Completed informational interview #2 <ul style="list-style-type: none"> ○ Name: Joel Hawkins ○ Organization: True Mettle Contracting Ltd. ○ Met at: True Mettle Rope Access Centre ● Completed informational interview #3 <ul style="list-style-type: none"> ○ Name: Steve Hands ○ Organization: MCL Height Safety ○ Met at: MCL Height Safety <p>(Note: A meeting log of all informational interviews is attached to the condensed logbook)</p> <ul style="list-style-type: none"> ● Looked up rope access worldwide employment statistics from the IRATA, SPRAT, as well as the Global Wind Organisation (GWO) trade associations, which I have just learned of from this week’s informational Interviews <p>https://www.globalwindsafety.org/statistics/global-wind-workforce-outlook-2024---2028</p>

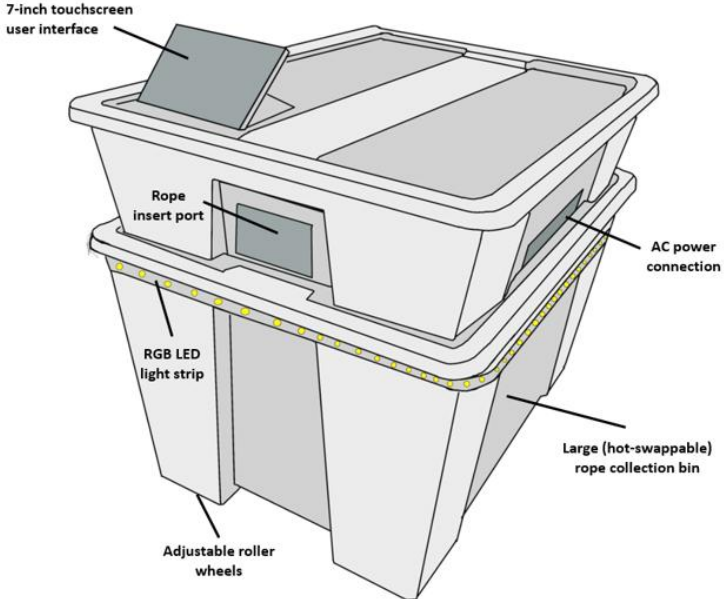
	<p>Technology Options</p>	<ul style="list-style-type: none"> • Learned of the Raspberry Pi camera module v3 and its ability to deliver 50fps at 1080p resolution https://datasheets.raspberrypi.com/camera/camera-module-3-product-brief.pdf • Researched USB UVC compliant web cameras to figure out what cameras on the market could match the frame rate of the Raspberry Pi camera module <p>Potential choices:</p> <ul style="list-style-type: none"> • ELP High Speed Webcam https://www.amazon.ca/ELP-Driver-windows-android-webcam/dp/B00KA7WSSU • OBSBOT Meet SE https://www.obsbot.com/obsbot-meet-se-full-hd-webcam • Elgato FACECAM 1080p60 Webcam https://www.elgato.com/ca/en/p/facecam-mk2
<p>Ideation – Week 8 (2025-09-28 – 2025-10-04)</p>	<p>Technology Options</p>	<ul style="list-style-type: none"> • Compared the feasibility of two options for the travel direction of the rope feeding inspection system (vertical vs horizontal) • Tested to see if higher frame rates lead to better image quality by testing the difference between the different camera framerate settings on my iPad Pro • Found that due to motion blur, the fine sheath pattern on the rope became a blur of colours and difficult to observe for damage even at 60 frames per second • Learned about the difference between rolling shutter and global shutter cameras and how global shutter cameras are far superior for capturing fast moving objects • Decided that I would be willing to go down to 3 camera feeds as it would ensure there would still be 360 degrees of camera coverage while reducing the risk of running out of USB port bandwidth • Found the Raspberry Pi Global Shutter Camera and noticed its relatively affordable price while delivering a 1.6-megapixel resolution

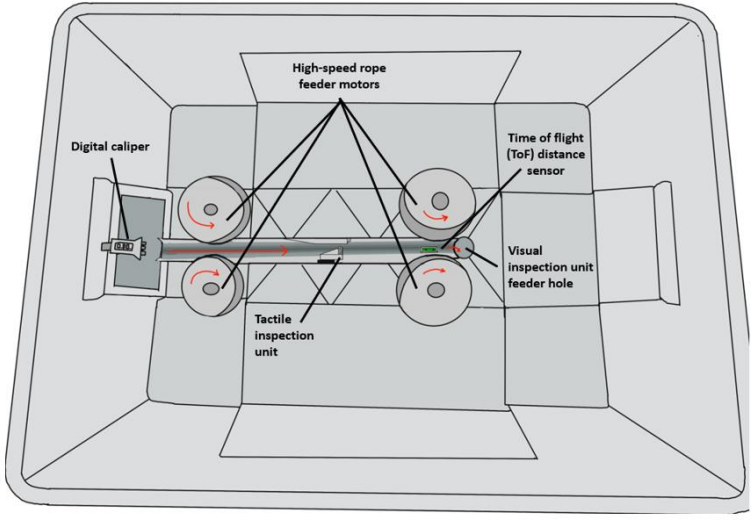
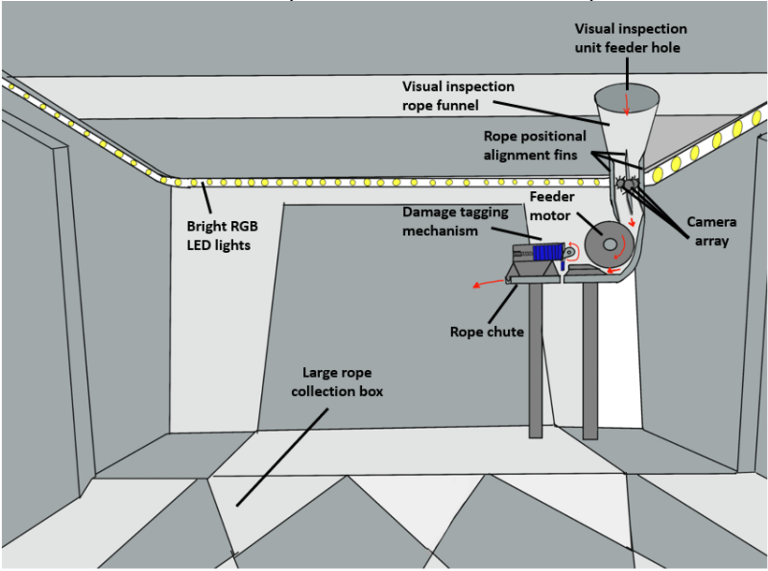
		<p>https://www.raspberrypi.com/products/raspberry-pi-global-shutter-camera/</p> <ul style="list-style-type: none"> Started compiling a preliminary material and technology list for purchase
	<p>Users' Needs</p>	<ul style="list-style-type: none"> Attended a community gear swap event to network with potential mountaineering professionals (ACMG) https://www.acmg.ca/ Obtained the contact information of two professional mountaineering organizations and subsequently scheduled informational interview #9 Created a summary document to capture the users' requirements by industry
<p>Ideation – Week 9 (2025-10-05 – 2025-10-11)</p>	<p>Users' Needs</p>	<ul style="list-style-type: none"> Completed informational interview #4 <ul style="list-style-type: none"> Name: Clayton Holt Organization: Apex Rope Industries, Inc. Met at: Apex Rope Industries, Inc. Confirmed with Mr. Holt the following NFPA rope performance requirements are still current: https://www.cmcpro.com/nfpa-1983-life-safety-performance-requirements/ Revised the list of questions for the shorter phone informational interview (printed copies of items discussed are filed in my project binder) Completed informational interview #5 <ul style="list-style-type: none"> Name: Chris Aziz Organization: Structure Group Ltd. Met at: phone call Completed informational interview #6 <ul style="list-style-type: none"> Name: Adam Gaulin Organization: Rope-A-Dope Windows Inc. Met at: phone call Completed informational interview #7 <ul style="list-style-type: none"> Name: Dries Van Hecke

		<ul style="list-style-type: none"> o Organization: Kiewit Construction Services ULC o Met at: phone call <ul style="list-style-type: none"> • Completed informational interview #8 <ul style="list-style-type: none"> o Name: Robert Romeril & Nicole Laforce o Organization: Arborist Supply Co. Inc. o Met at: Arborist Supply Co. Inc. <p>(Note: A meeting log of all informational interviews is attached to the condensed logbook)</p> <ul style="list-style-type: none"> • Read about the National Fire Protection Association (NFPA) standards on ropes used for fire / technical rescue https://www.nfpa.org/codes-and-standards/nfpa-1983-standard-development/1983 Video: Rope Rescue Training and Equipment Standards Combined https://www.youtube.com/watch?v=DfOZS5jMUhQ
	<p>Technology Options</p>	<ul style="list-style-type: none"> • When I asked if there was any value in tagging rope damages in some of the informational interviews, I received confirmation from the rope access professionals that tagging the rope damages would be helpful. So, I browsed options online to get inspiration from other industrial or manufacturing processes on how to mark / flag a damaged rope section post-inspection • Found multiple tagging solutions including bread sealers, craft tape / glue dot rollers, and bread tag staplers (the latter of which was my own idea) • Learned that the Raspberry Pi Global Shutter Camera was not compatible with the Nvidia Jetson Orin Nano Super Dev Kit as the IMX 296 sensor found inside is not supported unlike the IMX 708 sensors found in the non-global shutter Raspberry Pi cameras https://marketplace.nvidia.com/en-us/enterprise/robotics-edge/?category=cameras&page=1&limit=15

		<ul style="list-style-type: none"> • Researched other possible global shutter cameras the connect via CSI-2 but only found camera alternatives built on the much more expensive and difficult to get AR0234CS sensor https://www.e-consystems.com/nvidia-cameras/jetson-orin-nx-cameras/full-hd-ar0234-global-shutter-camera.asp
<p>Ideation – Week 10 (2025-10-12 – 2025-10-18)</p>	<p>Users’ Needs</p>	<ul style="list-style-type: none"> • Completed informational interview #9 <ul style="list-style-type: none"> o Name: Brent Peters o Organization: PeakSTRATAGEM o Met at: phone call <p>(Note: A meeting log of all informational interviews is attached to the condensed logbook)</p>
	<p>Technology Options</p>	<ul style="list-style-type: none"> • Found an alternative solution to the global shutter camera issue by learning that I could use an additional Raspberry Pi 5 board to capture the 3 camera feeds and route it via a Ethernet cable to the Nvidia Jetson Orin Nano Super Dev Kit https://www.youtube.com/watch?v=7Bz0QzIK6ps&t=1s • Decided to go with this ethernet solution as it would allow me to use a multi-camera array for 360-degree camera coverage while having minimal latency and set up work • Found a low-cost yet high quality USB UVC compliant Global Shutter Colour camera on Amazon, branded with the Arducam name https://www.amazon.ca/gp/product/B0CLXZ29F9
<p>Ideation – Week 11 (2025-10-19 – 2025-10-25)</p>	<p>Project Scope</p>	<ul style="list-style-type: none"> • Summarized all kernmantle rope safety standards and rope usage/inspection practices in various fields obtained to date, which will form the basis of the project scope and the project objectives: <ul style="list-style-type: none"> o To develop a portable, user-friendly system with AI capabilities that offers automated, rapid, and accurate kernmantle rope inspection. This innovation provides:

		<ul style="list-style-type: none"> ▪ Robust rope damage detection to offer actionable insights for maintenance and decision-making ▪ Comprehensive record keeping for enhanced rope lifecycle traceability, and ▪ Integration into industrial workflows for improved operational efficiency and safety
	<p>Users' Needs</p>	<ul style="list-style-type: none"> • Completed informational interview #10 <ul style="list-style-type: none"> ○ Name: Annie Hewitt ○ Organization: Canmore Cave Tours ○ Met at: phone call • Completed informational interview #11 <ul style="list-style-type: none"> ○ Name: Damian Sovd (TRT) & Joel Miller (FF) ○ Organization: Calgary Fire Department ○ Met at: Calgary Fire Department Windsor Park Emergency Response (Station 11) <p>(Note: A meeting log of all informational interviews is attached to the condensed logbook)</p> • Following interview #11, I read more about life safety rope (as defined by the NFPA Glossary, page 2589) inspection procedures used by the fire emergency services <p>Articles:</p> <ul style="list-style-type: none"> ○ Pro Tip: Inspecting Life Safety Rope https://www.cmcpro.com/pro-tip-inspecting-life-safety-rope/ ○ Is it Time to Retire Your Life Safety Rope? https://blog.qrfs.com/202-is-it-time-to-retire-your-life-safety-rope/
	<p>Technology Options</p>	<ul style="list-style-type: none"> • Learned of the Nvidia DeepStream SDK which is built off the GStreamer package to allow for ultra efficient AI processing of multiple video streams using batch processing <p>Links:</p> <ul style="list-style-type: none"> ○ Implementing Real-Time, Multi-Camera Pipelines with NVIDIA Jetson

		<p>https://developer.nvidia.com/blog/implementing-real-time-multi-camera-pipelines-with-nvidia-jetson/</p> <ul style="list-style-type: none"> ○ Nvidia DeepStream SDK https://developer.nvidia.com/deepstream-sdk
<p>Ideation – Week 12 (2025-10-26 – 2025-11-0)</p>	<p>Project Scope</p>	<ul style="list-style-type: none"> ● Made a final revision to the guiding question to incorporate the occupational aspects of rope inspection: <ul style="list-style-type: none"> ○ How might cameras and machine learning be utilized, along with current inspection techniques and occupational procedures, to inspect, monitor, and report the condition of kernmantle climbing and work-at-height safety ropes? ● Manually measured, inspected and prepared a total length of 540 meters of retired rope samples. All the damaged ropes were donated by the various informational interviewees I met with over the past 2 months ● Created a summary to outline my project scope
	<p>Conceptual Design</p>	<ul style="list-style-type: none"> ● Updated the conceptual design diagrams to show more details on the visual and tactile inspection modules in the 2 stacked enclosures <p>Conceptual design of the iRiS kernmantle rope inspection innovation</p>  <p>Labels in the diagram include: 7-inch touchscreen user interface, Rope insert port, AC power connection, RGB LED light strip, Large (hot-swappable) rope collection bin, and Adjustable roller wheels.</p>

		<p style="text-align: center;">Conceptual internal design of the iRiS kernmantle rope inspection innovation (top enclosure)</p>  <p style="text-align: center;">Conceptual internal design of the iRiS kernmantle rope inspection innovation (bottom / collection enclosure)</p> 
	<p>Technology Options</p>	<ul style="list-style-type: none"> Completed a check of my parts list, and will proceed with the procurement in the next project phase (Prototype)

Meeting Log with Work-at-Height Professionals

Inter view #	Date	Time	Interviewee	Role	Company	Meeting Location	Discussion Items	Retired Rope Donations (Y/N)
1	16-Sep-25	16:30-17:30	Simon Villeneuve	Director of Operations	Calgary Climbing Centre	CCC - Rocky Mountain	<ul style="list-style-type: none"> - What to inspect for - AB OHS regulations - Insurance liability - Current inspection record tracking 	Y
2	25-Sep-25	16:30-17:30	Joel Hawkins	Owner	True Mettle Contracting Ltd.	True Mettle Rope Access Centre	<ul style="list-style-type: none"> - IRATA member & member company - low-stretch vs. static vs. dyanmic rope - ISO & ANSI standards - IRATA certification & employment statistics - Where rope access is used (e.g. oil & gas, caving) - RFID / Serial number tagging - Request for making introductions to manufacturers and professionals in industrial and non-industrial sectors 	Y
			Kyle Egeland	Industrial Climber and Instructor, SPRAT Level 3				
3	26-Sep-25	15:00-16:00	Steve Hands	Training Manager	MCL Height Safety	MCL Height Safety	<ul style="list-style-type: none"> - Rope MBS and safety factors - GWO training / employment statistics / job market forecast - Major rope access companies in Canada - IRATA certified members Level distribution - Potential iRiS applications 	Y

Meeting Log with Work-at-Height Professionals

Inter view #	Date	Time	Interviewee	Role	Company	Meeting Location	Discussion Items	Retired Rope Donations (Y/N)
4	06-Oct-25	10:00-11:00	Clayton Holt	Co-Owner / Director	Apex Rope Industries Inc.	Apex Rope Industries, Inc.	<ul style="list-style-type: none"> - Confirmed the following NFPA rope performance requirements are still current: https://www.cmcpro.com/nfpa-1983-life-safety-performance-requirements/ - SPRAT certifications - Rope rescue (e.g. confined space) - Rope edge protection - Knot in rope breaking strength - Rope cleaning - Rope identification (RFID & QR codes) - Time spent derigging & inspecting - NFPA certification statistics and growth in developing regions 	Y
5	06-Oct-25	13:30-14:00	Chris Aziz	CEO / Owner	Structure Group Ltd.	Phone call	<ul style="list-style-type: none"> - Ropes used - Dynamic rope use applications - OHS regulations - Rope cleanliness - Ability to mark damaged areas of rope for better decision-making on rope maintenance vs rope retirement - Influence of economy on rope access industry 	N
6	06-Oct-25	15:30-16:00	Adam Gaulin	CEO / Owner	Rope-A-Dope Windows Inc.	Phone call	<ul style="list-style-type: none"> - Use of shock absorbers over dynamic rope or cow's tails - Rope length & storage - Rope standards and selection based on manufacuters specifications and static breaking strength - Hoisting rope fatigue - Ease of cleaning 	N

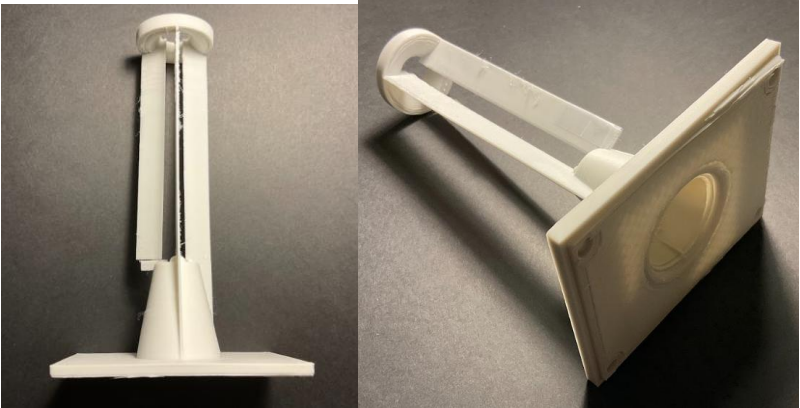
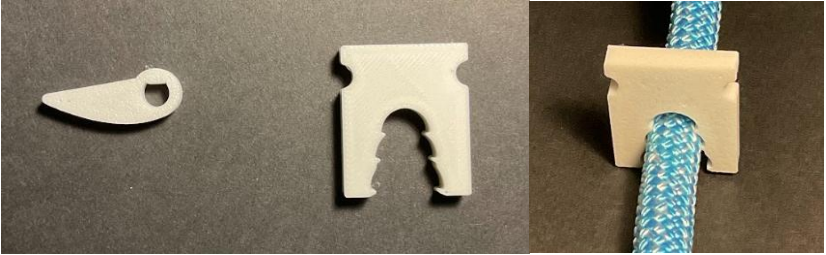
Meeting Log with Work-at-Height Professionals

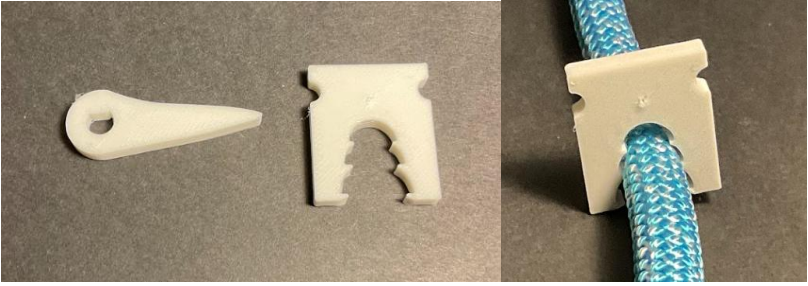
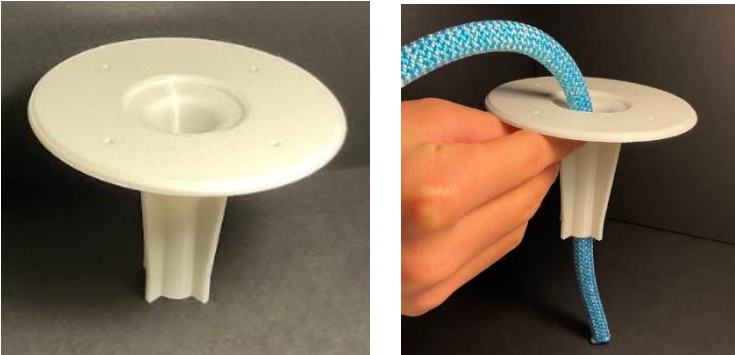
Inter view #	Date	Time	Interviewee	Role	Company	Meeting Location	Discussion Items	Retired Rope Donations (Y/N)
7	08-Oct-25	13:00-13:45	Dries Van Hecke	Superintendent / Geotechnical Rope Access SME	Kiewit Construction Services ULC	Phone call	<ul style="list-style-type: none"> - Roles on a rope access team - Rope colouring systems - Stiffness from contaminants - Human error (data entry & inspection) 	N
8	08-Oct-25	14:00-16:00	Robert Romeril	President and CEO	Arborist Supply Co. Inc.	Arborist Supply Co. Inc.	<ul style="list-style-type: none"> - Arborist rope & PPE ownership - Uses of the different plastic materials in ropes - Rope wash bags and hose washers - Working vs Rigging line vs Throwlines - Eyelets, splices, sewn-eye, spliced-eye - Tree climbing systems: MBS vs SBS - Arborist OHS regulations - Conflicts in practices - ISA certifications - Rope manufacturers - Ease of cleaning - Entertainment industry (Cirque du Soleil) 	Y
			Nicole Laforce	Sales Associate				
9	14-Oct-25	11:50-12:15	Brent Peters	IFMGA Mountain Guide, CAF Armoured Officer	PeakSTRATAGEM	Phone call	<ul style="list-style-type: none"> - Rope ownership - Rope diameters, lengths, and uses - Utilization of ropes in the Armed Forces - Cutting ropes into two to remove sections with damage 	N
10	22-Oct-25	16:55-17:25	Anne Hewitt	Senior Guide	Canmore Cave Tours	Phone call	<ul style="list-style-type: none"> - Only 10mm semi-static ropes are used - No sewn termination on ropes - Rope usage includes rappelling and personal lanyard - No power, wifi, cellular signal inside a cave 	Y
11	25-Oct-25	9:00-10:00	Damian Sovd	Technical Rescue Team (TRT)	Calgary Fire Department	Calgary Fire Department - Windsor Park Emergency Response (Station #11)	<ul style="list-style-type: none"> - Reducing forces by using low-stretch instead of dynamic ropes - Use of NFPA "T" and "G" rated ropes - Post-use / Pre-deployment inspections - Washing ropes 	N
			Joel Miller	Firefighter (FF)				

CYSF 2026 Logbook – Prototype Phase (November 2, 2025 – January 31, 2026)

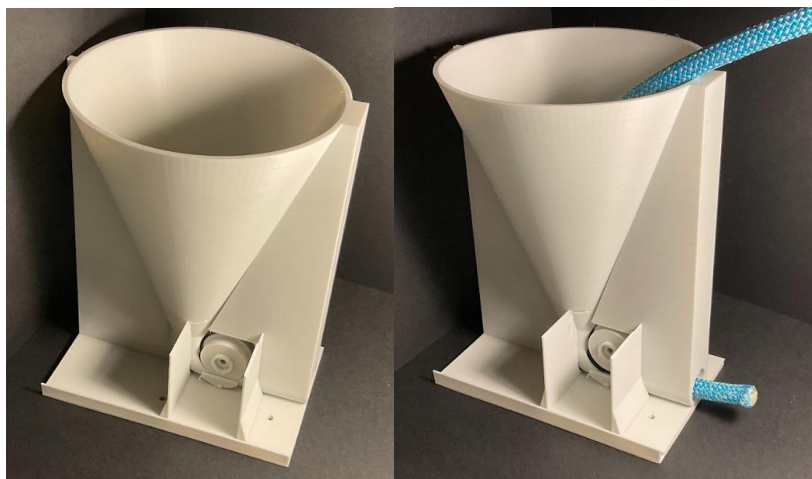
<p>Prototype – Week 13 (2025-11-02 – 2025-11-08)</p>	<p>Planning and Preparation</p>	<ul style="list-style-type: none"> • Took a modular design approach where the design and development of the iRiS system is subdivided into the following modules: <ul style="list-style-type: none"> ○ Module 1 – Enclosure ○ Module 2 – Visual Inspection using ML ○ Module 3 – Rope Feeder Assembly ○ Module 4 – User Interface ○ Module 5 – Tactile Measurement ○ Module 6 – Damage Tagging • Made some revisions to the Components List to balance local vs. online purchases, and also to list them by module • Placed orders for all components listed (Note: A full Components list is filed in the physical logbook) • Began the preparation and sorting of all rope samples into 4 categories: <ul style="list-style-type: none"> ○ A = As is – The rope is left untouched from its original condition ○ N = New – The rope is of new condition and was not used prior ○ S = Simulated damage – All rope damage was lab-simulated using various tools (e.g. rocks, bricks, BBQ lighter, box cutter) by causing abrasion, knicks, heat, blunt impacts, and cuts in an outdoor setting ○ B = Both as is and simulated damage – Damage on the rope was partially left as is and the remainder was damaged via lab-simulated means as described above
	<p>Module 1 – Enclosure</p>	<ul style="list-style-type: none"> • Measured the purchased plastic storage boxes to verify the sizing or quantity of various components to ensure fit
	<p>All Modules</p>	<ul style="list-style-type: none"> • Created a simplified Pictorial Electrical Diagram which includes all the electrical components for all modules as well as arrows indicating the direction of data / energy flow

		<p style="text-align: center;">iRiS Simplified Pictorial Electrical Diagram</p>
<p>Prototype – Week 14 (2025-11-09 – 2025-11-15)</p>	<p>Planning and Preparation</p>	<ul style="list-style-type: none"> • Completed preparing and sorting all 70 (uncut) rope samples outdoors. Compiled a detailed inventory list in preparation for the creation of the machine learning image dataset <ul style="list-style-type: none"> ○ See document filed in the physical logbook
	<p>Module 2 - Visual Inspection</p>	<ul style="list-style-type: none"> • Created a 3D CAD model and then 3D printed the version 1 of the rope guidance component in the visual rope inspection system <ul style="list-style-type: none"> ○ Learned that this design fits smaller ropes but broke when larger ropes were run through indicating a lack of strength <div style="text-align: center;"> </div> <ul style="list-style-type: none"> • Designed and 3D-printed version 2 of the rope guidance system with a minor design modification

		<ul style="list-style-type: none">○ I added additional material to the CAD model to reinforce the three guide rails; however, the printed component was still not strong enough to reliably support the ropes weight especially when under tension 
	<p>Module 6 – Damage Tagging</p>	<ul style="list-style-type: none">• Designed and 3D-printed a preliminary CAD model for the plastic damage tags and the corresponding stepper motor attachment gear  <ul style="list-style-type: none">○ The interior diameter of the 3D-printed stepper motor gear was slightly larger than the CNC milled shaft of the stepper motor and will need to be adjusted in the design to fit properly○ As designed, the damage tag fit with the various rope sizes, however, once placed it would not stay on due to the teeth of the tag being too small and not sharp enough to grasp the rope tightly

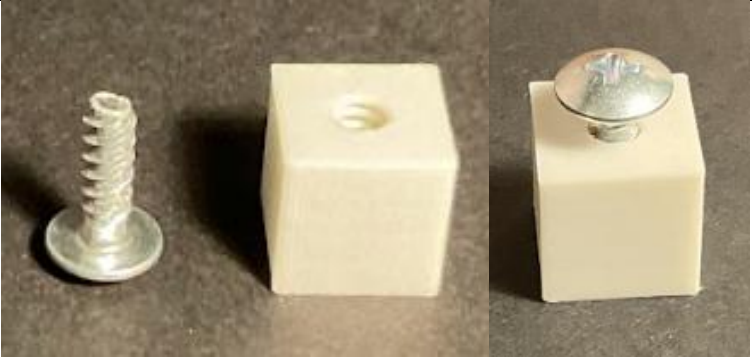
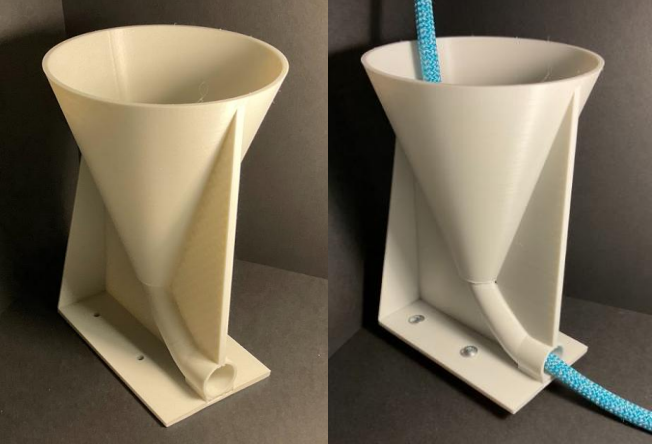
		<ul style="list-style-type: none"> Redesigned the stepper motor gear and damage tag with the improvements mentioned above and 3D-printed the file 
<p>Prototype – Week 15 (2025-11-16 – 2025-11-22)</p>	<p>Module 2 - Visual Inspection</p>	<ul style="list-style-type: none"> Given the first two prototypes demonstrated that the vertical guide rails were unable to support the rope’s acting forces, I experimented with a different approach. <ul style="list-style-type: none"> I ran a rope through a large kitchen funnel to test how well the funnel’s shape controlled the swaying motion of the rope while actively being lowered down the neck of the funnel Mimicking the funnel shape concept, I overhauled the design of the rope guidance component in the visual rope inspection system <ul style="list-style-type: none"> Designed and 3D-printed version 3 of the rope guidance system Tested the printed version 3 model with ropes of multiple diameters (8 mm to 12.5 mm) Found that this new model successfully limited the swaying motion of the rope while smoothly feeding the rope through the system 

	<p>Module 3 – Rope Feeder Assembly</p>	<ul style="list-style-type: none"> • Began CAD modelling a preliminary rope feeding unit to house the motors and provide compressive forces to pinch and move the rope forward
<p>Prototype – Week 16 (2025-11-23 – 2025-11-29)</p>	<p>Module 3 – Rope Feeder Assembly</p>	<ul style="list-style-type: none"> • Completed CAD modelling of the preliminary rope feeding unit by cutting out wire holes and adding slider bars to keep the feeder motors in place
	<p>Module 2 - Visual Inspection</p>	<ul style="list-style-type: none"> • 3D modeled and printed the version 1 bottom feeder assembly using a funnel shaped cone, right angle shaped tube, and a feeder wheel that could be attached to a stepper motor <ul style="list-style-type: none"> ○ Found that it was difficult to run ropes through the bottom feeder assembly that were thicker than 11mm in diameter without having to remove the feeder wheel ○ Decided that I would move the motor to outside of the bottom feeder assembly as it would simplify the design ○ Learned that the angle of the 90-degree shaped tube needs to be steeper to allow the rope to smoothly pass through ○ I showed my dad the printed model and the issue of the rope catching on the 90-degree shaped tube. Upon seeing my printed model, he thought it looked similar to a catenary curve, and thus suggested I look into the concept of a catenary curve



		<ul style="list-style-type: none">• After learning about Catenary curves from online resources, I found that its formula would be applicable to my project as it models the U-shaped curve that is created by the gravitational pull on a flexible material that is strung from 2 points Resources:<ul style="list-style-type: none">○ Britannica – Hyperbolic Functions https://www.britannica.com/science/hyperbolic-functions○ The Catenary: A Vector Calculus Problem https://www.youtube.com/watch?v=-xYUxxDDP6E○ Learned that I could modify the shape of a catenary curve by changing the coefficient in the formula of $(y = a \cosh(x/a))$ rather than individually modifying variables such as the objects tension or weight○ During math class at school, we were learning about how to find the line of best fit so I realized that by hanging my different samples of rope from the same two points, I could find the average curve and compare that to find the best coefficient for a catenary curve that could be used to model the next iteration • Conducted an experiment where I plotted the curve of different diameter rope samples onto graph paper, hung from points suspended 200mm apart and above the ground, allowing the curve of the rope to almost touch the ground, thus simulating the rope being run through the planned dimensions of the bottom feeder assembly
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		<div data-bbox="631 193 1117 596" data-label="Figure"> </div> <div data-bbox="1117 193 1446 596" data-label="Image"> </div> <ul data-bbox="678 646 1437 850" style="list-style-type: none"> • Using the determined equation of $(y = 5 \cosh(x/5))$ obtained from the catenary curve experiment, I redesigned the curve of the bottom feeder assembly by removing both the feeder wheel and the motor housing from the design <div data-bbox="727 856 1003 1249" data-label="Figure"> </div>
<p>Prototype – Week 17 (2025-11-30 – 2025-12-06)</p>	<p>Module 2 - Visual Inspection</p>	<ul data-bbox="678 1327 1437 1570" style="list-style-type: none"> • Learned about the different screw measurement systems and printed out a test screw hole block for the screws I planned to use to fasten the bottom feeder assembly to the plastic bin enclosure https://www.mcmaster.com/info/how-to-measure-screw-thread-size.html

		 <ul style="list-style-type: none"> • Finished modeling and 3D printed the version 2 bottom feeder assembly <ul style="list-style-type: none"> ○ Found that the printed model worked very well and allowed ropes of diameters up to 13mm to run through the bottom feeder assembly without the need of an additional motor to help pull the rope through 
		<ul style="list-style-type: none"> • Tested the responsiveness of the ELP Global Shutter Camera and began 3D modeling a mount for the camera https://www.amazon.ca/gp/product/B0CXDS8F6Q • Determined that the ELP Global Shutter camera needed to be at least 190mm away from an object in order to have a 100mm vertical camera field of view
<p>Prototype – Week 18 (2025-12-07 – 2025-12-13)</p>	<p>Module 2 - Visual Inspection</p>	<ul style="list-style-type: none"> • 3D printed and tested the version 1 ELP Global Shutter Camera mount <ul style="list-style-type: none"> ○ Found the five M2.5 screw holes to fit well and distribute the load evenly

- The mount supported the camera load adequately



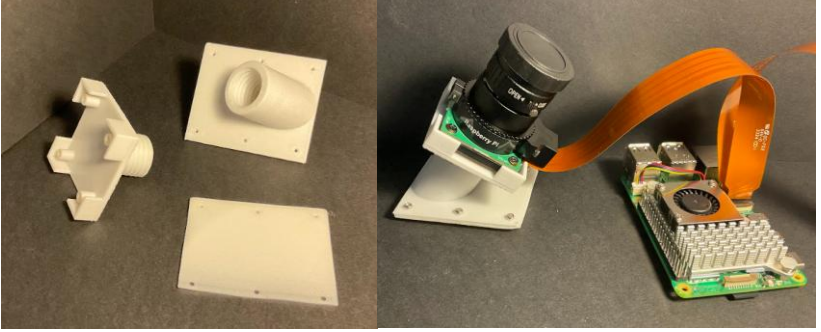
- Installed the operating software (via a microSD card), global shutter cameras, and the fan heatsink on the Raspberry Pi 5 and booted it up using Raspberry Pi Connect

Resources used:

- Raspberry Pi Remote Access - 3 Methods <https://www.youtube.com/watch?v=l4VDWhKsFgs>
- Raspberry Pi Documentation - Getting Started <https://www.raspberrypi.com/documentation/computers/getting-started.html>
- When installing the Raspberry Pi Global Shutter Cameras, I realized I ordered regular CSI to CSI cables instead of CSI to MiPi CSI 2 cables, luckily 200mm cables were included in the camera box, which allowed me to continue to work on the project while new 500mm ones were shipped in from DigiKey Electronics
- Adjusted the focus on both the Raspberry Pi cameras and the ELP Global Shutter camera individually by manually passing commands via the command terminal

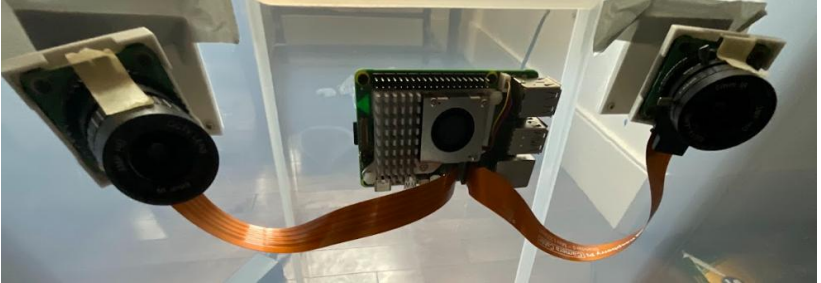
Resources used:

		<ul style="list-style-type: none"> ○ Setup the Raspberry Pi HQ Camera in 3 minutes https://www.youtube.com/watch?v=2lh76103XVk ○ Raspberry Pi High Quality Camera – Tutorial https://core-electronics.com.au/guides/raspberry-pi-high-quality-camera/ ○ Camera - Raspberry Pi Documentation https://www.raspberrypi.com/documentation/accessories/camera.html#gs-camera ○ Set Up USB Camera for OpenCV Projects with Raspberry Pi https://randomnerdtutorials.com/set-up-usb-camera-opencv-raspberry-pi/ ○ On the Raspberry Pi, I created a virtual environment called “projectCode” in the system folder I named CYSF26 ○ Made the USB camera test code following an online tutorial which I used to test and adjust the ELP Global Shutter Camera ○ Used the following commands in the terminal to run the Raspberry Pi cameras individually: <ul style="list-style-type: none"> ▪ Camera in CAM-0 slot: <code>rpicam-hello --camera 0 --timeout 0 -f</code> ▪ Camera in CAM-1 slot: <code>rpicam-hello --camera 1 --timeout 0 -f</code> ● Determined that the Raspberry Pi Global Shutter cameras needed to be at least 200mm away from an object to have a 100mm vertical camera field of view ● 3D modeled and printed out the first version of the Raspberry Pi Global Shutter Camera mounts <ul style="list-style-type: none"> ○ Used a screw-based design based on a paper towel holder to allow the camera to be positioned either closer or further away from the rope ○ Took the 200mm value I got from testing the camera into account when considering how far away I should design the camera mount
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	<p>Module 3 – Rope Feeder Assembly</p> <p>and</p> <p>Module 5 - Tactile Measurement</p>	<ul style="list-style-type: none"> • Soldered the stacking header pins and regular header pins onto the time-of-flight sensor and all three Adafruit motor shields • Tested each motor shield by running 12v through the input and checking for a power light • Tested the adjustable power supply with a multimeter to check the voltage readings • Tested the barrel jack breakouts to make sure the polarity markings were accurate
	<p>Module 5 - Tactile Measurement</p>	<ul style="list-style-type: none"> • Soldered the header pins on the HX711 load cell board and the level-shifter
<p>Prototype – Week 19 (2025-12-14 – 2025-12-20)</p>	<p>Module 2 - Visual Inspection</p>	<ul style="list-style-type: none"> • Downloaded and successfully imaged Jetpack v6.2 onto the Jetson Orin Nano Tutorial used: <ul style="list-style-type: none"> ○ NVIDIA Jetson Orin Nano - SSD & MicroSD Setup Guide https://www.youtube.com/watch?v=BaRdpSXU6EM • Tested controlling the Jetson Orin Nano using the 7” touchscreen and the on-screen keyboard • Tried remoting into the Jetson Orin Nano from my laptop via SSH using PuTTY and successfully gained terminal access

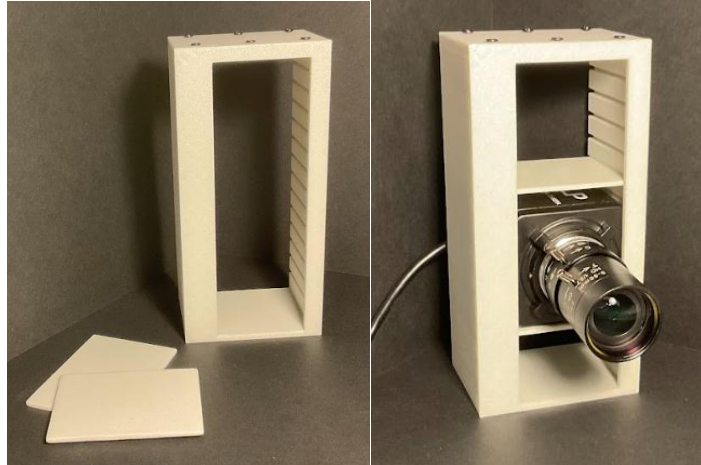
		<ul style="list-style-type: none"> • Set up the Ethernet connection between the Raspberry Pi and the Jetson Nano Resources: <ul style="list-style-type: none"> ○ How to Set Up a Static IP Address on the Raspberry Pi https://www.youtube.com/watch?v=qy1_jV1fgJU ○ How to Set Static IP for Jetson https://www.forecr.io/blogs/connectivity/how-to-set-static-ip-for-jetson • Gave both the ethernet connections on each device a permanent IP address that was completely different than the ones used by my home internet router <ul style="list-style-type: none"> ○ Jetson Nano: 192.168.0.2/24 ○ Raspberry Pi: 192.168.0.1/24
	All modules	<ul style="list-style-type: none"> • Exchanged emails with a Canadian rope manufacturer, Braids and Laces
<p>Prototype – Week 20 (2025-12-21 – 2025-12-27)</p>	<p>Module 2 – Visual Inspection</p>	<ul style="list-style-type: none"> • Looked into the Nivida DeepStream SDK to learn how to implement a pipeline to house and run my device’s inspection process Resources: <ul style="list-style-type: none"> ○ Welcome to the DeepStream Documentation https://docs.nvidia.com/metropolis/deepstream/dev-guide/text/DS_Overview.html ○ DeepStream Quickstart Guide https://docs.nvidia.com/metropolis/deepstream/dev-guide/text/DS_Quickstart.html#platform-and-os-compatibility ○ Python Sample Apps and Bindings Source Details https://resources.nvidia.com/en-us-deepstream-get-started-with-python <ul style="list-style-type: none"> ○ DeepStream SDK Python bindings and sample applications

		<p>https://github.com/NVIDIA-AI-IOT/deepstream_python_apps</p> <ul style="list-style-type: none"> ○ Samples for TensorRT/DeepStream for Tesla & Jetson https://github.com/NVIDIA-AI-IOT/deepstream_reference_apps ○ Nvidia DeepStream 101: A beginner's guide to real-time computer vision https://chirag4798.medium.com/nvidia-deepstream-101-a-beginners-guide-to-real-time-computer-vision-afefcb5d7fba ○ Nvidia DeepStream 101: A step-by-step guide to creating your first DeepStream application https://chirag4798.medium.com/nvidia-deepstream-101-a-step-by-step-guide-to-creating-your-first-deepstream-application-68148753cf96 <ul style="list-style-type: none"> ● Created python script which uses a GStreamer pipeline and OpenCV functions to take each of the 3 cameras streams and create 3 windows that would stream the camera feed live to my display Tutorials used: <ul style="list-style-type: none"> ○ Camera software - Raspberry Pi Documentation https://www.raspberrypi.com/documentation/computers/camera_software.html ○ Python OpenCV: Capture Video from Camera https://www.geeksforgeeks.org/python/python-opencv-capture-video-from-camera/ ○ Accessing the Raspberry Pi Camera with OpenCV and Python https://pyimagesearch.com/2015/03/30/accessing-the-raspberry-pi-camera-with-opencv-and-python/ ○ Multiple cameras with the Raspberry Pi and OpenCV - PyImageSearch
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		<p>https://pyimagesearch.com/2016/01/18/multiple-cameras-with-the-raspberry-pi-and-opencv/</p> <ul style="list-style-type: none">○ Set Up USB Camera for OpenCV Projects with Raspberry Pi Random Nerd Tutorials https://randomnerdtutorials.com/set-up-usb-camera-opencv-raspberry-pi/○ OpenCV for Raspberry Pi - Full Course https://www.youtube.com/watch?v=YFvBkMV6Dml○ How to get GStreamer and OpenCV to work with a Raspberry Pi AI camera with a CSI connection. https://www.youtube.com/watch?v=J_ihGvGUGHA <ul style="list-style-type: none">● Adjusted the pixel size of the cameras in the script and found that the USB global shutter camera could only display in resolutions that followed a 4:3 aspect ratio so I rotated the USB camera view 90 degrees to create a tall rectangular view rather than a wide one and resized all of the cameras to stream in a resolution of 480 pixels wide by 640 pixels high https://www.geeksforgeeks.org/python/python-opencv-cv2-rotate-method/● Test-fitted the Raspberry Pi and Raspberry Pi cameras and marked the holes to drill● Drilled out holes and mounted the raspberry pi and the Raspberry Pi cameras onto the shorter-end wall of the lower enclosure bin 
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- Attempted to mount the ELP global shutter but realized my original design of the camera mount would not work as the camera needed to be turned 90 degrees to display the vertical image in a 480-by 640-pixel format

- Redesigned the camera mount and 3D printed it



- Drilled holes and installed the bottom feeder assembly



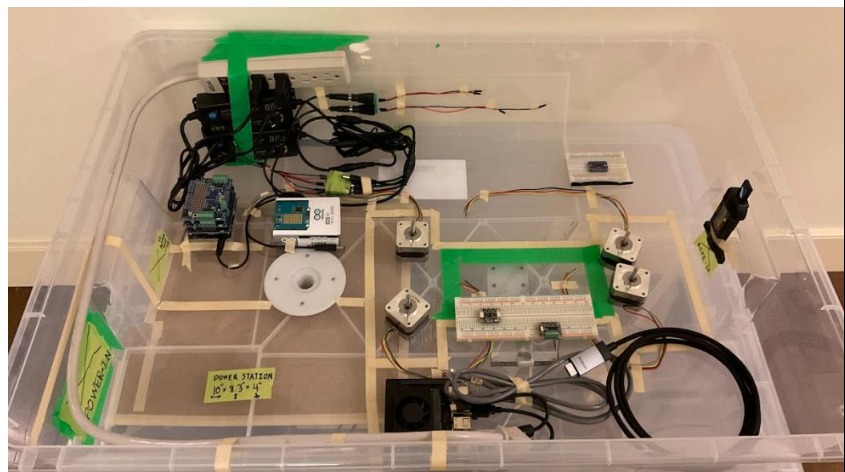
- Installed the rope funnel device through the lid of the lower bin and the bottom of the upper bin by drilling and melting the plastic material around it



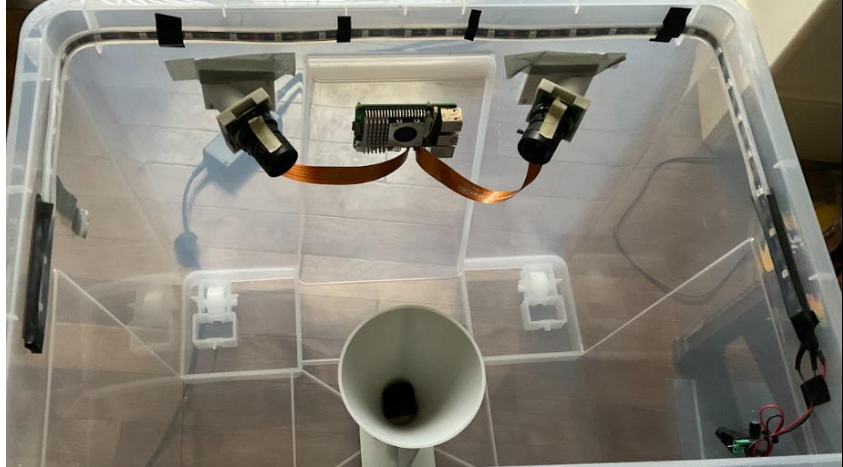
- Installed the 3D-printed ELP camera mount and then installed the camera



- Measured out a 10 x 8.3 x 4.4-inch box in the upper bin to reserve space for a potential battery upgrade and arranged the wiring layout for all of the internal components around the rope pathways and rope feeder assembly



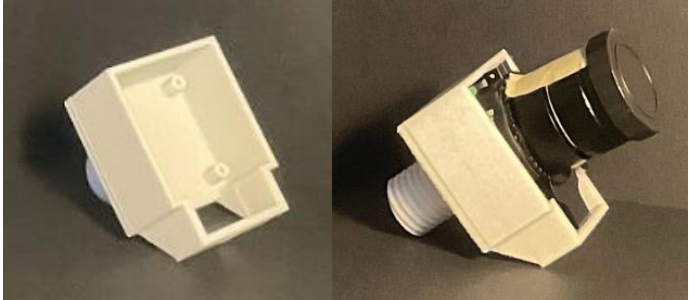
- Installed the LED light strip using magnets and electrical tape, making sure to solder on a 470-ohm resistor and attach a capacitor to the screw block



- Created an Arduino script that set the LED strip light colour to white and realized that the bright light was reflecting off the rope's sheath and causing glare on the surface of the rope seen by the camera during low light conditions

Tutorials:

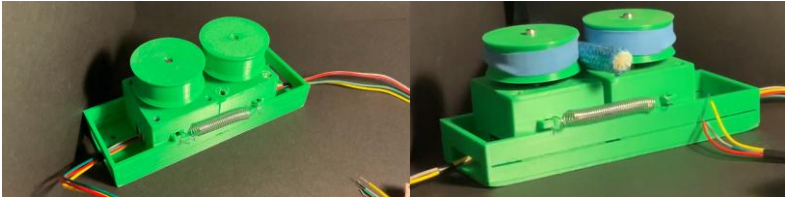
- Adafruit NeoPixel GitHub Repository
<https://github.com/adafruit/Adafruit-NeoPixel>
- Adafruit NeoPixel Uberguide
<https://learn.adafruit.com/adafruit-neopixel-uberguide>
- Using miscellaneous screws, I mounted the power bar and both of the Adafruit Adjustable Power Supply units to the side of the upper bin, making sure that the location allowed enough slack in the wiring to reach each component
- One of the Raspberry Pi camera mounts broke so I reprinted the part and reinforced it by spreading a layer of superglue to bind the layers of filament

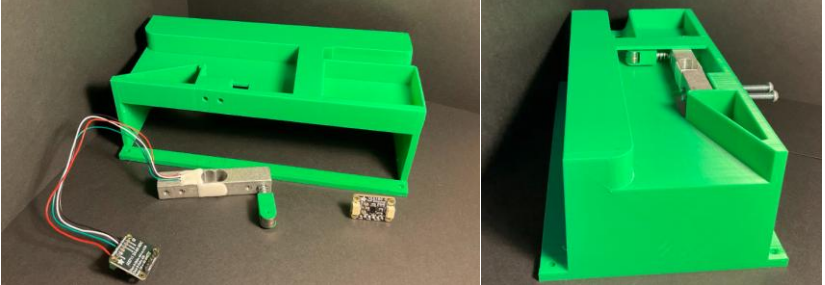
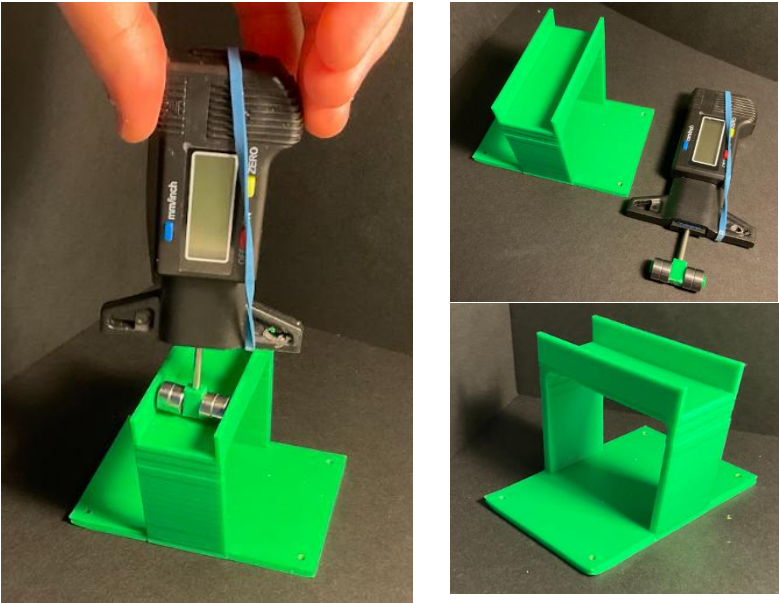
		<p>together, however the part continued to break after the superglue was applied</p> <ul style="list-style-type: none"> To reduce the chance of the Raspberry Pi camera breaking, I redesigned the new camera mount using a screw mount design  <ul style="list-style-type: none"> Attempted to diffuse the bright LED strip light using kraft paper but found that it wasn't effective at reducing the glare on the sheath of the rope Used a piece of aluminum foil as a lamp shade on the portions of the LED strip that directly face each of the cameras and found that it effectively reduced the glare but made the background of each image inconsistent due to a colour difference between the kraft paper and the shiny aluminum foil
	<p>Module 1 - Enclosure</p>	<ul style="list-style-type: none"> Checked to see the area of which the transparent lower bin and aluminum foil was seen in the background by the cameras and pasted kraft packaging paper onto inside to create a consistent (non-reflective) backdrop
	<p>Module 3 – Rope Feeder Assembly</p>	<ul style="list-style-type: none"> I connected the motor's leads up to the extender ribbon cables and arranged them into a wiring harness that could be easily connected to the Arduino Motor Shield Block
	<p>Module 5 – Tactile Measurement</p>	<ul style="list-style-type: none"> Using my pinout guide that I drafted up when purchasing parts (see document filed in the physical logbook), I connected the load cell to the HX711 sensor board and then connected the HX711 board and the Time-of-Flight sensor up to the Arduino using a breadboard and jumper cables

<p>Prototype – Week 21 (2025-12-28 – 2026-01-03)</p>	<p>Module 2 – Visual Inspection</p>	<ul style="list-style-type: none"> • Collected the data for the machine learning model by taking images in 2 batches (new and used/as is condition) <ul style="list-style-type: none"> ○ Manually took images of the 17 new ropes in my rope collection to ensure the new ropes would not come into contact with dirt/debris from the used ropes ○ Then took images of the remaining 53 ropes with varying levels of damage <p>Collected a total of 6517 images:</p> <ul style="list-style-type: none"> ▪ 3236 images were assigned to the “Good” image class (images where no visible damage can be observed) ▪ 3281 images were assigned to the “Bad” image class (images where damage can be visibly observed) ○ Did not take pictures of some ropes that had been intentionally set aside and left “as-is” to save them for future testing with the machine learning model <ul style="list-style-type: none"> • Explored the collected data to confirm that an equal distribution of images was obtained between the two classes • Explored the use of transfer learning to train my CNN image classification model and their pros and cons https://www.ibm.com/think/topics/transfer-learning • Decided that I would attempt to train my model via transfer learning as it saves time over training a traditional model and would be much more efficient for my low-power hardware plus limited access to GPU training resources on Google Colab • Researched different CNN architectures and decided on using the EfficientNetB5 architecture as its input shape of 456x456 pixels meant that I
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		wouldn't have to compress my 480x640 pixels images but could just crop down to the 456x456 pixels size instead https://keras.io/examples/vision/image_classification_efficientnet_fine_tuning/
Prototype – Week 22 (2025-01-04 – 2025-01-10)	Module 2 – Visual Inspection	<ul style="list-style-type: none"> • Cleansed the data - manually sorted through the images and removed images that were either not an accurate representation of its class (i.e. "Good" or "Bad") or that were placed into the wrong image class by mistake <ul style="list-style-type: none"> ○ Removed a total of 123 non-representative images resulting in a final total dataset of 6394 original images • Continued to prepare the data by resizing all images in the dataset to a size of 456x456 pixels using Microsoft PowerToys
	All modules	<ul style="list-style-type: none"> • Exchanged emails with an international rope manufacturer, Edelrid
Prototype – Week 23 (2025-01-11 – 2025-01-17)	Module 2 – Visual Inspection	<ul style="list-style-type: none"> • Prepared the data by splitting the images using Google Colab to create 3 subsets: with 60% for training (3836 original images), 20% for validation (1279 original images), and 20% for testing (1279 original images) following the recommendation from an article Article: <ul style="list-style-type: none"> ○ Dataset & Dataset Splitting in Machine Learning https://medium.com/@asifurrahmanaust/lesson-1-dataset-dataset-splitting-in-machine-learning-7881526f4fc3 Tutorials: <ul style="list-style-type: none"> ○ Easy way to split data on your disk into train, test, and validation https://www.youtube.com/watch?v=C6wbr1jJvVs ○ Tutorial: How to Automatically Split Your Data (in Folders) Using Python

		<p>https://www.youtube.com/watch?v=sAD3-Xl0j4g</p> <ul style="list-style-type: none">• Given the portability of the device, I tried out augmenting a subset of the training data (10 original images from each of the Good and Bad classes) by modifying their brightness, contrast, saturation, and hue, to determine which of these changes will lead to realistic image representations under various lighting conditions. The purpose of such data augmentation is to improve the tolerance of the machine learning model's performance in various lighting conditions as well as to reduce overfitting https://pixflow.net/blog/master-hue-saturation-and-luminance-the-ultimate-guide-to-color-theory/<ul style="list-style-type: none">○ After reviewing the results of the data augmentation prototyping, I chose to only augment the original images using a combination of random changes to the brightness, contrast, and saturation within predefined upper and lower limits. No changes to the hue because the prototype produced augmented images that look unrealistic○ The training dataset increased in size from 3836 original images to roughly a total of 7672 images (both original plus augmented) <p>Tutorials used:</p> <ul style="list-style-type: none">○ Pytorch Data Augmentation using Torchvision https://www.youtube.com/watch?v=Zvd276j9sZ8○ How to build custom Datasets for Images in Pytorch https://www.youtube.com/watch?v=ZoZHd0Zm3RY○ ColorJitter — Torchvision main documentation
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		<p>https://docs.pytorch.org/vision/main/generated/torchvision.transforms.ColorJitter.html#:~:text=class%20torchvision.transforms.,Should%20be%20non%2Dnegative%20numbers</p> <ul style="list-style-type: none"> ○ PyTorch – Randomly change the brightness, contrast, saturation and hue of an image https://www.tutorialspoint.com/pytorch-randomly-change-the-brightness-contrast-saturation-and-hue-of-an-image
	<p>Module 3 – Rope Feeder Assembly</p>	<ul style="list-style-type: none"> ● Revised the rope feeder unit CAD model to fit the dimensions measured in the upper bin and reinforce the sidewalls of the motor housings ● 3D printed the rope feeder unit to test fit the components before printing out the second unit for the upper bin  <ul style="list-style-type: none"> ○ Added rubber bands to the outer surface of the feeder wheels to increase the amount of grip the motors have on the rope ○ Learned that the screw holes of the motor housings were misaligned but luckily did not impact the strength or function of the part ○ Installed the two feeder units into the upper bin of the device using eight 2.5mm screws
	<p>Module 5 – Tactile Measurement</p>	<ul style="list-style-type: none"> ● Designed, 3D printed and installed the tactile sensing unit which utilizes a load cell, a spring, and bearings to sense the compressibility of the rope. A friction mount for a Time-of-Flight sensor was also included to allow for the addition of a length measurement feature later

		 <ul style="list-style-type: none"> • Designed, 3D printed and installed the rope diameter sensing assembly into the top bin of the device 
<p>Prototype – Week 24 (2025-01-18 – 2025-01-24)</p>	<p>Module 2 – Visual Inspection</p>	<ul style="list-style-type: none"> • Developed the code to use transfer learning to train the model in Google Colab Tutorials: <ul style="list-style-type: none"> ○ Learn PyTorch for deep learning in a day. Literally. https://www.youtube.com/watch?v=Z_ikDlimN6A <ul style="list-style-type: none"> ▪ CNN Explainer https://poloclub.github.io/cnn-explainer/ ○ Build Your First Pytorch Model In Minutes! [Tutorial + Code] https://www.youtube.com/watch?v=tHL5STNJKag

		<ul style="list-style-type: none"> ○ Using Transfer Learning With Neural Networks: Pytorch Deep Learning Tutorial https://www.youtube.com/watch?v=WhD4iDEW4w4 <ul style="list-style-type: none"> ▪ Transfer Learning - Notebook https://github.com/LukeDitria/pytorch_tutorials/blob/main/section05_transfer_learning/notebooks/Pytorch1_Transfer_Learning.ipynb ○ Pytorch Transfer Learning and Fine Tuning Tutorial https://www.youtube.com/watch?v=qaDe0qQZ5AQ ○ Efficient Image Classification with Transfer Learning and Image Augmentation with TensorFlow Keras https://www.youtube.com/watch?v=CLHk6DniYg0 ○ PyTorch Tutorial 15 - Transfer Learning https://www.youtube.com/watch?v=K0IWSB2QoIQ ○ Transfer learning - explained (VGG16, MobileNet, ResNet, EfficientNet) https://www.youtube.com/watch?v=YaBX-eNdYGw • Began training and testing models with different hyperparameters such as batch size and epochs <ul style="list-style-type: none"> ○ Trained all the models with everything but the final layer frozen ○ Recorded the results in my Machine Learning Log (filed in the Physical logbook, and it will also be uploaded as an attachment to the CYSF portal) • Began training, testing, and recording the data of the Machine Learning models <ul style="list-style-type: none"> ○ Found that over a 5-epoch run, the batch size of 32 generated the best results ○ Found that when training with a fully frozen backbone, the accuracy began to plateau
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		<p>after the 20th epoch with minimal improvements afterwards</p> <ul style="list-style-type: none"> • Learned that the initial learning rate of 1e-3 produced the best results as it more quickly updated the weights resulting in a higher accuracy and lower loss in the earlier epochs <ul style="list-style-type: none"> ○ See the machine learning log filed in the physical logbook for my analysis
	All modules	<ul style="list-style-type: none"> • Exchanged emails and had a 30-minute phone call with an international rope manufacturer, Petzl
<p>Prototype – Week 25 (2025-01-25 – 2025-01-31)</p>	<p>Module 2 – Visual Inspection</p>	<ul style="list-style-type: none"> • Finished training, testing, and recording the data of the Machine Learning models (refer to the Machine Learning Log for details including accuracy, observations, results, and plots of loss and accuracy on both sets of testing and validation data) <ul style="list-style-type: none"> ○ Attempted to further improve the performance of the model by gradually unfreezing the blocks in the EfficientNetB5 architecture over a 20-epoch training period Tutorials used: <ul style="list-style-type: none"> ▪ Guide to Freezing Layers in PyTorch: Best Practices and Practical Examples https://medium.com/we-talk-data/guide-to-freezing-layers-in-pytorch-best-practices-and-practical-examples-8e644e7a9598 ▪ PyTorch Tutorial 15 - Transfer Learning https://www.youtube.com/watch?v=K0IWSB2QoIQ <ul style="list-style-type: none"> • pytorchTutorial/Transfer Learning https://github.com/patrickloeber/pytorchTutorial/blob/master/15_transfer_learning.py

		<ul style="list-style-type: none">○ Found that gradually unfreezing blocks 6-8 was extremely helpful along with the use of decreasing the learning rate over time as it raised the model's accuracy from 90-92% to 94-96% depending on the specific model Tutorials used to decrease the learning rate:<ul style="list-style-type: none">▪ torch.optim — PyTorch 2.7 documentation https://docs.pytorch.org/docs/stable/optim.html▪ Learning Rate Scheduling in PyTorch https://codesignal.com/learn/courses/pytorch-techniques-for-model-optimization/lessons/learning-rate-scheduling-in-pytorch▪ Using Learning Rate Schedule in PyTorch Training https://machinelearningmastery.com/using-learning-rate-schedule-in-pytorch-training/○ Coded a script to test the top 4 models (out of a total of 14 models) on the test dataset and output the performance using Scikit-learn metrics to generate a confusion matrix and classification report<ul style="list-style-type: none">▪ Using the information from the confusion matrices and the classification reports, I selected the version 12 model to be the “final” model of which I will run on the device for testing and deployment <p>Tutorials used:</p> <ul style="list-style-type: none">▪ Confusion matrix and test accuracy for PyTorch Transfer Learning tutorial https://stackoverflow.com/questions/53290306/confusion-matrix-and-test-accuracy-for-pytorch-transfer-learning-tutorial▪ How to Plot Confusion Matrix in PyTorch?
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		<p>https://stackoverflow.com/questions/74020233/how-to-plot-confusion-matrix-in-pytorch</p> <ul style="list-style-type: none"> ▪ PyTorch Beginner Tutorial - Part 11 (Test the Model) https://www.youtube.com/watch?v=JeP9CVC8XIU
	Module 3 – Rope Feeder Assembly & Module 5 – Tactile Measurement	<ul style="list-style-type: none"> • Soldered jumper wires to the depth gauge’s output pads and used solder to assign each Adafruit Motor shield a unique I2C address • Connected all the wiring for the tactile sensors and the motors up to the 2 Arduinos
	All Modules	<ul style="list-style-type: none"> • Confirmed each module of the device is fully assembled and all three foundational blocks of iRiS (i.e. the mechanical system, computing hardware, and machine learning algorithms) are ready for testing in the next project phase

Components Procurement List for the Prototyping of iRiS

Module	Part Name	Quantity	Vendor	Price (\$CAD)	Link
Module 1 - Enclosure	IKEA SAMLA storage box with Lid, 130L	1	IKEA	26.99	https://www.ikea.com/ca/en/p/samla-box-with-lid-transparent-s29440819/
	IKEA SAMLA storage box with Lid, 55L	1	IKEA	16.99	https://www.ikea.com/ca/en/p/samla-box-with-lid-transparent-s39440814/
	Misc. Screws	1	Memory Express	9.99	https://www.memoryexpress.com/Products/MX79608
Module 2 - Visual Inspection	Jetson Orin Nano Super Developer Kit	1	Amazon	356.13	https://www.amazon.ca/NVIDIA-Jetson-Orin-Nano-Developer/dp/B0BZJTQ5YP
	128GB Kingston Micro SD Card with adapter	1	Staples	17.99	https://www.staples.ca/products/2968117-en-kingston-128-gb-microsdxc-canvas-select-plus-g3-with-sd-adapter?
	Raspberry Pi Global Shutter Camera	2	PiShop	144.90	https://www.pishop.ca/product/raspberry-pi-global-shutter-camera/
	6mm Wide Angle Lens for Raspberry Pi Global Shutter Camera	2	PiShop	72.90	https://www.pishop.ca/product/6mm-wide-angle-lens-for-raspberry-pi-hq-camera-cs/
	1m Flex Cable for Raspberry Pi	2	PiShop	9.90	https://www.pishop.ca/product/flex-cable-for-raspberry-pi-camera-1-meter/
	Raspberry Pi 5 8GB	1	PiShop	115.95	https://www.pishop.ca/product/raspberry-pi-5-8gb/
	64GB Kingston Micro SD Card	1	Vision Electronics	5.00	https://www.visions.ca/kingston-64gb-canvas-select-plus-uhs-i-microsdxc-memory-card-with-sd-adapter-sdcs3-64gb?
	Raspberry Pi Active Cooler	1	PiShop	7.00	https://www.pishop.ca/product/raspberry-pi-active-cooler/
	Raspberry Pi Official Power Supply 45W	1	PiShop	21.45	https://www.pishop.ca/product/raspberry-pi-45w-usb-c-power-supply-white/
	ELP USB UVC Global Shutter Camera	1	Amazon	124.88	https://www.amazon.ca/gp/product/B0CXDS8F6Q
	Adafruit LED Light Strip	1	PiShop	14.95	https://www.pishop.ca/product/adafruit-neopixel-digital-rgb-led-strip-black-30-led-black/
	470 ohm Resistor (4-pack)	1	Solarbotics	2.30	https://www.solarbotics.com/product/470-ohm-1-4w-resistor-4-pk/
1000 uF Capacitor (5-pack)	1	Solarbotics	5.80	https://www.solarbotics.com/product/capacitor-1000uf-35v-electrolytic-radial-5-pk/	
Module 3 - Rope Feeder Assembly	Arduino Uno R4 Wifi	1	Solarbotics	39.95	https://www.solarbotics.com/product/arduino-uno-r4-wifi/
	Adafruit Motor Shield v2.3	3	PiShop (2) & DigiKey (1)	93.31	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/1438/5353647
	Adafruit Shield Stacking Headers	2	PiShop	4.90	https://www.pishop.ca/product/shield-stacking-headers-for-arduino-r3-compatible/
	Adafruit NEMA 17 Motors	5	DigiKey	103.40	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/324/5022791
	5-amp Adjustable Desktop Power Supply	2	DigiKey	51.70	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/4880/13908443
	4-Way Barrel Jack Splitter	2	DigiKey	14.62	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/1352/5761223
	Barrel Jack Female Breakout	3	DigiKey	17.70	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/368/5629434
	Assorted Spring Set	1	Amazon	17.24	https://www.amazon.ca/dp/B000K7M36W?th=1
Adafruit VL6180X Time-of-Flight Distance Sensor	1	DigiKey	20.60	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/3316/6569763	
Module 4 - User Interface	DisplayPort to HDMI Unidirectional Cable	1	Memory Express	24.99	https://www.memoryexpress.com/Products/MX00130634
	7" IPS Touchscreen with Case	1	PiShop	84.95	https://www.pishop.ca/product/7inch-hdmi-lcd-h-display-with-case-1024x600-ips/
Module 5 - Tactile Measurement	Arduino Uno R4 Wifi	1	Home (reuse)	0.00	
	Adafruit HX711 Expansion Board for Load Cell	1	DigiKey	15.67	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/5974/24639130
	Adafruit 5KG Load Cell	1	DigiKey	5.83	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/4541/12323573
	Digital Tire Tread Depth Gauge with Battery	1	Amazon	10.49	https://www.amazon.ca/gp/product/B0BKQGW3XL
	8-channel Level Shifter / Converter	1	Solarbotics	4.89	https://www.solarbotics.com/product/logic-level-converter-8ch-bi-txs0108-spi-uart/
Ball Bearings, ID 1/8" x OD 3/8" x Width 5/32" , 10-pack	1	Amazon	11.59	https://www.amazon.ca/gp/product/B0C74WTY1K	
Module 6 - Damage Tagging	Adafruit NEMA 17 Motors	1	DigiKey	20.68	https://www.digikey.ca/en/products/detail/adafruit-industries-llc/324/5022791

CYSF 2026 Logbook – Testing and Deployment Phase (February 1–28, 2026)

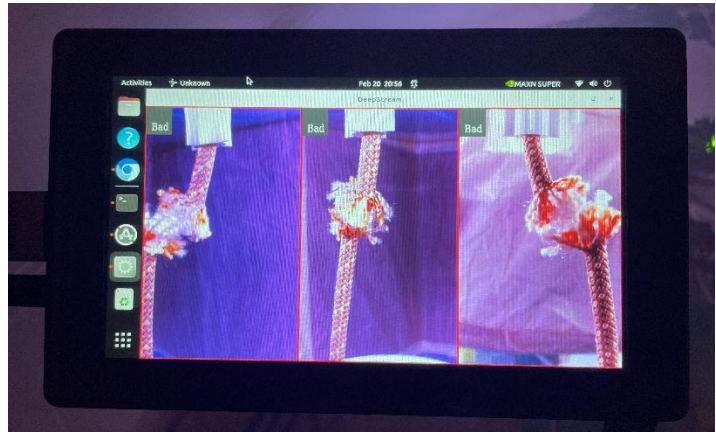
<p>Testing – Week 26 (2025-02-01 – 2025-02-07)</p>	<p>Module 3 – Rope Feeder Assembly</p>	<ul style="list-style-type: none"> • Connected the motors to the stack of Adafruit motor shields and began testing with the sample code to determine how to control them <ul style="list-style-type: none"> ○ 2 of the 3 motor shields did not work for some unknown reason and were unable to be tested, thus I had to reorder them from DigiKey Electronics as well as the soldered-on stacking headers Product Links: <ul style="list-style-type: none"> ○ https://www.digikey.ca/en/products/detail/adafruit-industries-llc/85/5154649 ○ https://www.digikey.ca/en/products/detail/adafruit-industries-llc/1438/5353647
	<p>Module 5 – Tactile Measurement</p>	<ul style="list-style-type: none"> • Determined the Mac addresses of the two Arduinos using a BLE script <ul style="list-style-type: none"> ○ Tactile sensing Arduino: B4:3A:45:33:9F:40 ○ Motor controller Arduino: F4:12:FA:68:EA:58 • Combined the example Time-of-Flight sensor, Load cell, and LED light strip Arduino code into one script with both Bluetooth and non-Bluetooth capabilities • Attempted to read the data off from the digital tire depth gauge but found the sample code from the video tutorial to not work but instead print symbols in the serial monitor Caliper and Arduino i2c - measure 3D filament https://www.youtube.com/watch?v=tTV52DihPTc <ul style="list-style-type: none"> ○ Attempted to resolder the wire connections on the board of the digital caliper but the solder pads on the board melted and fell off ○ Decided to set the digital caliper functionality aside for now as readings could still be read off of the LCD screen
	<p>Module 2 – Visual Inspection</p>	<ul style="list-style-type: none"> • Connected the touchscreen up to the Jetson Orin Nano, mounted it to the enclosure, and connected the ethernet cable to the Raspberry Pi

<p>Testing – Week 27 (2025-02-08 – 2025-02-14)</p>	<p>Module 3 – Rope Feeder Assembly</p>	<ul style="list-style-type: none"> • Received the 2 new Adafruit motor shield boards and installed them into the system, which then allowed the motors to finally run <ul style="list-style-type: none"> ○ Found out that the last remaining motor shield from my first batch of orders stopped working without any obvious reason ○ Accidentally fried the motor shield Arduino by having the 12v barrel jack port (meant for motor power only) connected to the motor shield while the vin jumper was connected essentially circulating 12-volts through a system meant to only handle 5-volts ○ Purchased a new Arduino Uno R4 Wi-Fi from Solarbotics to replace the one I had fried ○ Added an extra step to release the stepper motors in the Arduino script before turning off power to preserve the life of the motor shields
	<p>Module 2 – Visual Inspection</p>	<ul style="list-style-type: none"> • Begun developing the Nvidia Deepstream pipeline by downloading the Deepstream SDK as well as the python Deepstream bindings library (pyds) from the online catalog Links: <ul style="list-style-type: none"> ○ Nvidia DeepStream SDK https://catalog.ngc.nvidia.com/orgs/nvidia/resources/deepstream/files?version=7.1 • Installed all the other required dependencies by following these tutorials: <ul style="list-style-type: none"> ○ Nvidia Deepstream SDK https://docs.nvidia.com/metropolis/deepstream/7.1/text/DS_Quickstart.html ○ Deepstream 101 a beginners guide to real time computer vision https://chirag4798.medium.com/nvidia-deepstream-101-a-beginners-guide-to-real-time-computer-vision-afefcb5d7fba ○ Deepstream 101 a step-by-step guide to creating your first deepstream application https://chirag4798.medium.com/nvidia-deepstream-101-a-step-by-step-guide-to-

		<p>creating-your-first-deepstream-application-68148753cf96</p> <ul style="list-style-type: none">• Begun working on the Raspberry Pi side of the script by attempting to modify my original camera script which I used for taking pictures Tutorials:<ul style="list-style-type: none">○ USB/CSI Camera for a Webcam on Stream https://guides.platerecognizer.com/docs/stream/help/usb-camera/#:~:text=Create%20a%20folder%20on%20your,Dshow%20Parameters%20used○ AI on the Jetson Nano LESSON 62: Make a Streaming IP Camera from a Raspberry Pi Zero W https://www.youtube.com/watch?v=7Bz0QzIK6ps○ Switched to a purely GStreamer pipeline rather than using OpenCV to stream the USB camera feed for simplicity○ Copied the same exact camera paths as in the original “PiStreamer” code that I used to take the pictures of the ropes to avoid compatibility issues○ Added in the Jetson’s IP address functionality so that the streams would be sent over the Ethernet cable• Created a labels.txt file making sure to correctly order the “Bad” and “Good” labels so that the Jetson would know how to correctly label the classifications based on my model’s predictions• Created the config.txt file by copying the structure of the examples found on the Nvidia Deepstream GitHub repository and replacing their example model with my own custom EfficientNet converted to onnx model file Deepstream python apps https://github.com/NVIDIA-AI-IOT/deepstream_python_apps/tree/master/apps• Created the main.py file based on the GitHub examples and YouTube tutorials to build the TensorRT engine, but my engine file would not build no matter what I tried
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		<p>Resources:</p> <ul style="list-style-type: none"> ○ Deepstream reference apps https://github.com/NVIDIA-AI-IOT/deepstream_reference_apps/tree/master ○ How to Run Multiple Streams with DeepStream SDK on Jetson Nano using Ultralytics YOLOv8 Episode 82 https://www.youtube.com/watch?v=wWmXKit eRLA ○ The model would consistently attempt to build the engine file going through the cycle of showing high RAM and GPU utilization before powering back down and never actually completing the building of the engine file and thus never running the inference
<p>Testing – Week 28 (2025-02-15 – 2025-02-21)</p>	<p>Module 2 – Visual Inspection</p>	<ul style="list-style-type: none"> ● Given the unpredictability of the main.py file that I was attempting to use last week, I switched to running the main file on a .txt file instead of a python file as it would theoretically give me better reliability and consistent results when running my model, however, this would mean that I wouldn't be able to connect to the Arduinos until I moved back to a python script later <p>Resources:</p> <ul style="list-style-type: none"> ○ Deepstream reference apps example source4_1080p_dec_parallel_infer.yml https://github.com/NVIDIA-AI-IOT/deepstream_reference_apps/blob/master/deepstream_parallel_inference_app/tritonclie nt/sample/configs/apps/bodypose_yolo/source4_1080p_dec_parallel_infer.yml ○ The Friendly Guide to build DeepStream Application https://maouriyen.medium.com/the-friendly-guide-to-build-deepstream-application-3e78cb36d9f2 ○ Found that this solution was more reliable and allowed me to finally build the TensorRT engine and run inference on samples on real-time

- Added the functionality in the main.txt file to show bounding boxes around the frame to show the per-frame predictions on screen



- Set the '**classifier-threshold**' to a value of 0.5 so that the predictions displayed would have had to have at least a 50% or greater confidence score
- Noticed that the frames of the USB camera were very slow to load on the Jetson's screen and had a grainy texture
 - Reduced the framerate down to 10 FPS and lowered the bitrate to try to save some bandwidth and RAM which would allow me to load all 3 cameras without issues
 - Fiddled with the GStreamer camera system and modified the system to route the streams to a MediaMTX router which would hold the streams until the Jetson Nano connects to the Raspberry Pi and then hands them off to the Jetson Nano to run inference
 - This would make the camera feeds smoother and have the system drop frames instead of trying to send old ones making the footage look smoother and use less RAM

Resources:

- How to Stream Video from Raspberry Pi Effortlessly
<https://www.youtube.com/watch?v=rxtcyxV32nc>
- MediaMTX

		<p>https://github.com/bluenvirion/mediamtx X</p> <ul style="list-style-type: none"> ▪ Testing low-latency live streams on a Raspberry Pi 5 and Camera Module 3 https://github.com/Nerdy-Things/raspberry-pi-5-live-stream/ ▪ Part 1: Building Your First Video Pipeline: FFmpeg & MediaMTX Basics https://hackernoon.com/part-1building-your-first-video-pipeline-ffmpeg-and-mediامتx-basics ▪ Ultra Low Latency Streaming Raspberry Pi + Python + WebRTC + MediaMTX https://www.youtube.com/watch?v=gAqdzWVAuo <ul style="list-style-type: none"> • Successfully ran multiple ropes of different diameters and lengths through iRiS to complete an end-to-end cycle of a rope inspection solely using the onboard motors • Noticed that while iRiS was running, a power draw warning on the Jetson Nano would appear even though I was on the most intensive “Maxim Super” mode which would allow the Jetson board to draw up to 25 watts of power, this was likely due to the fact that I was drawing an amp of power via USB for the touch screen which could alternatively be powered by an external battery or power brick in the future for reliability
	<p>Module 5 - Tactile Measurement</p>	<ul style="list-style-type: none"> • Performed two unit tests on the digital caliper and load cell to test their ability to recognize rope damage in the data (refer to test data recorded in the physical logbook) <ul style="list-style-type: none"> ○ Using 10 different data points placing both bad and good sections of 5 ropes under the sensors to compare the resulting data values ○ Found that the digital caliper was 1-2 mm off from the manufactured rope diameter but could accurately sense for sections of rope that felt significantly thinner

		<ul style="list-style-type: none"> ○ Found that it was difficult to gauge the data from the load cell to determine whether damage was present in comparison to the other sections of the rope <ul style="list-style-type: none"> ▪ Determined that a value decrease of 80,000 or more between data points usually indicated rope damage
<p>Testing and Deployment – Week 29 (2025-02-22 – 2025-02-28)</p>	<p>Module 3 – Rope Feeder Assembly</p>	<ul style="list-style-type: none"> • Tested the speed of the motors by conducting 3 trials of ropes of 3 different diameters (8.2mm, 9.8mm, 12.2mm) and then recording the length of rope they were able to pull through the system in 100 seconds <ul style="list-style-type: none"> ○ Found that ropes of approximately 10mm in diameter were pulled through the system fastest at a speed of 4.1cm/s whereas the motors struggled on thicker ropes ○ Refer to test data recorded in the physical logbook
	<p>Module 2 – Visual Inspection</p>	<ul style="list-style-type: none"> • Six retired ropes, with a total length of 176.5 meters, in their original state of use in an indoor setting (with no simulated damages added) had been previously set aside for this ‘real-world’ deployment testing purpose as these “unseen” ropes had not been used in the development and/or validation of the machine learning model • Tested the deployment accuracy of the machine learning model with the above six unseen ropes using this comparison technique <ul style="list-style-type: none"> ○ Identified the ground truth prior to running the test which included 60 (20 x 3 camera frames) instances of “good” samples and 60 (20 x 3 camera frames) instances of “bad” samples per rope based on my own observation ○ Collected a total of 720 ground truth data points (360 “good” and 360 “bad”) across the 6 unseen ropes based on my own observation, classification and recording

		<ul style="list-style-type: none">○ To compare the ground truth to the predictions as reported by iRiS, I placed each of these 20 “good” and 20 “bad” sample instances per rope in each of the 3 camera views and then manually recorded whether the iRiS model correctly classified the sample or not as shown on the screen○ Of the 720 ground truth data points, iRiS reported 338 “good” instances and 312 “bad” instances) as shown on its screen○ Found that the model’s accuracy roughly matched the trends found with the testing dataset during model validation where the model struggled more on classifying the “bad” samples○ The model had an overall combined accuracy of roughly 90%<ul style="list-style-type: none">▪ 86.6% accuracy on “bad” samples▪ 93.8% accuracy on “good” samples○ Refer to test data recorded in the physical logbook
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