CPE495
G10: Rio & Tate

Components	Price	Description/Name	Link
Motion Sensor	$24.99	Lorex add-on motion sensor. Passive infrared motion sensor to add simple video-free security.	Lorex
Motion Sensor Camera	$22.99	2k Pan/Tilt Security Camera. Has night vision and AI Motion Detection	Amazon
Motion Sensor Camera	$17.99	Compact indoor plug-in camera with night vision and motion detection	Amazon
Connectors		Need additional female-to-female connectors/wires	
nRF24L01+	~12$	Radio Transceiver 2.4Ghz	Amazon
SoC with radio transmitter		More research needs to be done	

Notes:
- SoC with radio transmitter
- Research on Components:
  - PiR Motion Sensor ()
  - JemRF Motion Sensor ($24.95)
  - M.2 SSD
  - Raspberry Pi Computer Module CM4 IO Board ($35.00)
  - Raspberry Pi 5 w/ 4GB RAM (CanaKit, $60.00)
  - Raspberry Pi AI Kit (Vilros, $70.00)
  - Nano Pi w/ Hat
- "Coral and CM4 are a no go, Coral seems to work on the Pi 5 (GitHub discussion)
- Notes below from quick hardware meeting:
  - Note: need female-to-female connectors
  - Possibly get Raspberry Pi 5 at Gigaparts (4gb ram)
  - Possibly get compute kit with Hailo
  - Need motion sensor
  - <mark>We were able to get female to female connectors from Dr. Jovanov</mark>

Prompt:
- https://www.nasa.gov/smallsat-institute/sst-soa/soa-communications/
  - Encryption
  - Antennas

- Radio Transceiver
  - https://forum.arduino.cc/t/nrf24l01-improve-range-between-pa-lna-sma-antenna-version-and-basic-version/636006/2
    - Discussions about the nRF24L01+
  - https://hallard.me/nrf24l01-real-life-range-test/
    - One blog showcases that some issues may arise in the transmittance of the information, but multiple solutions can be employed.
      - Compression (i.e. delta, and general)
      - Antenna
    - Has ability to transfer at 250Kbs to 2Mbps
      - 250Kbs seems to be more robust for areas with obstacles
- What are Radars?
  - Radar, electromagnetic sensor used for detecting, locating, tracking, and recognizing objects of various kinds at considerable distances. It operates by transmitting electromagnetic energy toward objects, commonly referred to as targets, and observing the echoes returned from them.
- How can radar be used?
  - RADAR is helpful in detecting incoming signals during war and also used by a geologist for earthquake detection. Archaeologists use this technology for detection of buried artifacts. It is also used to understand the environment and climatic changes.

- What are some components we can get?
  - We are not planning to have a built-in radio transmitter on our microcontroller
- Short-Range Radio Communication Protocols:
  - LoRa
    - Physical proprietary radio communication technique
    - Define a low-power wide-area networking protocol designed to wirelessly connect battery operated devices to the Internet
    - Uses license=free radio frequency bands
    - Enables long-range transmission with low power consumption
    - Uses a proprietary spread spectrum modulation that is similar to and a derivative of chirp spread spectrum modulation.
  - Zigbee
    - Specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios.
    - Intended to be simpler and less expensive than other wireless personal area networks (i.e. Bluetooth, Wi-Fi)
    - Seems to have applications with short-range low-rate wireless data transfer
  - Custom RF Modules
    - Highly customizable, reasonable power consumption
    - Moderate bandwidth which does limit quality of image transfer
    - But, is suitable for moderate image transfer

- Some Hardware Components that may be required for this smart trail camera
  - Core computing and Storage
    - Trail Cameras whether cellular or non-cellular generally use SD Cards to store the images locally. It is possible to utilize a MicroSD Card or an external SSD if our database is too large
  - Camera Module
    - As for now we have settled with the Raspberry Pi Camera Module. It seems to have a high enough resolution for wildlife tracking and is much easier to connect with the device. We spoke about using a NoIR version of the Pi Camera which would help for night vision.
    - As a future addition we could utilize a lens filter. We had spoken about using a fisheye lens for larger viewing space but training it with the module would be much more difficult. This would be the same with using a 360 degree lens.
  - Wireless Communication
    - We would like to stay away from cellular communication as cellular trail cameras have begun attempting to implement a form of classification. We would like to work with Bluetooth and Radio Transceivers instead. We are looking into using custom RF modules.
    - Some other possibilities were LoRa, LoRaWAN, and Zigbee but we do not think we will be using those
  - Motion Detection
    - PIR (Passive Infrared) Sensor to trigger the camera only when motion is detected
  - AI/ML
    - Using a Coral USB Accelerator, Tensorflow Lite, PyTorch, or a Hailo-8 Edge AI processor for offloading AI inference tasks. We are thinking of using the Coral USB Accelerator for our alert system prototype.
  - Power Supply
    - Looking at a 30k mAh battery. Some other alternatives are portable power banks or rechargeable battery packs.
  - Enclosure
    - May need to implement some form of weather-proofing to the trail camera.
  - Miscellaneous Components
    - Real-Time Clock Module for accurate timekeeping and timestamping for pictures
    - GPS module or tracking module to ensure you can track the trail camera if it has been stolen
    - LEDs for light
    - SD Card Reader or a USB Hub to house the SD Cards
  - Sensors
    - Alongside the PIR Sensor to trigger the camera for motion detection we may utilize a temperature sensor to determine internal temperature.

- Additional resources or discussions on radio image transfer:
  - [Discussion of radio image transfer using Raspberry Pi and Arduino](#)
  - [Short explanation on how radio waves become a picture](#)
  - [Discussion post on Quora about image radio transfer](#)

Additional component, research, or discussion links:
- [Prototyping with Coral TPU](#)
- [Microcontroller with Coral TPU](#)
- [Possible Issues](#)
- [Possible Issues #2](#)
- [CM4 IO Board](#)
- [Video explaining Wi-Fi on LoRaWAN bands](#)
- [GSM Shield for Raspberry Pi](#)
- [Cuddeback (Existing trail camera)](#)
- [Spypoint (Existing trail camera)](#)
- [Heat Pipe for Raspberry Pi 4](#)
- [Wireless transceiver module](#)
- [LoRa vs. Zigbee](#)
- [How LoRa transmits images](#)
- [HaLow vs LoRaWAN](#)
- [HaLow Wi-Fi Standard (1KM)](#)
- [High performance open source radio](#)
- [Arduino wireless communication tutorial](#)
- [Pi 4 communication with nRF24L01](#)
- [Pi 4 connection with nRF24L01](#)
- [Another wireless transceiver module](#)