IR SCOUT

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The Motivation

- On a daily basis, first responders are tasked with entering dangerous, often unknown environments.
- These environments usually have little or no visibility due to smoke or other debris.
- The IR Scout addresses these issues by providing the user with remote, thermal reconnaissance of the hazardous area.
The Concept

- The IR Scout is a highly durable sensor package that wirelessly transmits high-quality, thermal images to a remote user.
Overview

Power-on device and throw device → Device Stabilizes → Sensor Data sent to Tiva µC → I2C → Tiva µC uses data to determine orientation of device

Receive Lepton camera data from one camera → UART → Send data to WiFly module → MATLAB receives data and displays images

Repeat 6 Times
Components

FLIR Lepton
- The main component of our product

Accelerometer (MMA8452Q)
- Needed for stabilization

Tiva C Launchpad Microcontroller
- Fast enough clock for Lepton SPI
- Interfaces Camera modules with SPI
- Sends Data to WiFly

RN- XV WiFly
- Acts as a UDP data pipeline from Tiva C to laptop.

Fuel Tank Booster Pack
- Powers all components and attaches to Tiva C Launchpad
Stabilization

- Read accelerometer data
- Waits 3 seconds
- Read accelerometer data second time
- Checks to see if both readings are the same
- If yes, device is stable
Orientation Algorithm

Problem
- Need to snap image from top 6 cameras only
- Requires knowledge of device orientation

Solution
- Set a default orientation based on camera locations relative to accelerometer axis
- Gravity from 3 axis accelerometer can be used to calculate roll and pitch but not yaw
- Use angles rotated along x and y axis build rotational matrices Rx and Ry
- Rotational matrices used to find new relative location
  - Can’t find exact location but can find location along Z height
- If Z component positive, camera snaps image
MATLAB Simulations

Default

\[ \theta_x = 26.35 \quad \theta_y = 50.71 \]
Acquiring Image Data

The Lepton uses a unidirectional SPI connection.

As you can see the MOSI line is not used since the Lepton only sends data to the host.
Acquiring Image Data

The Lepton uses SPI Mode 3

- Chip Select is active low
- Data changes on the falling edge of SCK
- Data is sampled on the rising edge of SCK
Acquiring Image Data

Screen Shot of Lepton Packets from Logic Analyzer
Acquiring Image Data

- Once Chip Select is sent low the Lepton begins to send data down the MISO line
- The data is separated into 164 byte packets that must be read in by the host at a minimum frequency
- The packets can be either a discard packet or a line of the frame
Discard Packets

- In between frames the Lepton sends discard packets down the MISO line
- If the last four bits of the second byte is equal to 15 its a discard packet
Data Packets

- One frame of the Lepton comes in packets of 164 bytes which represent one line of the image
- The second byte of the packet denotes the line number of the packet
Sending Image Data using WiFly

- Data from Tiva C Microcontroller is sent to WiFly Module using UART Connection
- Wireless transmission with Wifly using UDP Protocol
- UDP Protocol is faster than TCP/IP Protocol due to less checks between sender and receiver.
- Send image data in 10 packets each containing 6 lines to MATLAB
  - 9840 bytes per image
- Attempted TCP/IP Protocol for more secure data transfer using Processing Program. Proved to be unreliable at sending large amounts of data.
MATLAB Image Retrieval

- Import Java Libraries to MATLAB to enable UDP capabilities for student version
- Wireless transmission from Wifly using UDP
- Receive image data in 10 packets each containing 6 lines to MATLAB
  - 984 byte packets
- If part of packet is dropped, MATLAB will send line of dropped packet initiating a packet resend
  - Ensures images will always be sent
- If no packets dropped, 6 images captured and sent wirelessly in around 35 seconds - if packets are dropped it takes a little longer
- Process of capturing and retrieving image data repeated until all 6 images received by MATLAB
MATLAB Display

- Convert the image data from a 60x164 matrix to a 60x80 image
- Interpolation is performed on the image to enlarge it

Original Image

Interpolated Image
MATLAB Display

- A custom color map is then applied to the image.
Results

- Stabilization and orientational algorithm after throwing
- Camera Module PCB manufactured
- SPI image data retrieval from Lepton camera
- Capture and Send 6 images wirelessly in approximately 35 seconds
- Display Images on a Laptop via MATLAB
Problems to Overcome

New issue: Lepton configured to operate with only one master and one slave. We can’t have multiple Lepton Modules on the same SPI bus.

Possible Solution: Use MUX implementation to allow only one Lepton module to be connected to master device at a time. MUX used to switch between modules.
MUX Solution

Tiva C

MUX

MISO_1
MISO_2
MISO_3

MISO

MISO_12
Future goals

● Convert the MATLAB user interface into a mobile application. This will allow for a more compact, practical product.

● Expand on the number of cameras in the throw-able sensor package

● Combine both visual and thermal cameras in the device and then use FLIRs MSX blending algorithm to give a more detailed view

● Add video streaming for one camera module at a time.

● Rotate the images so that they are all oriented correctly
THE END

Questions?