Project 2 Lessons
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Functions can be abstractions

• Hide details from their “callers”

• In our case: we are hiding the details of the analog interface and how to interpret the analog values

• Functions should adhere to their specification and do no more
Project 3: Lateral Velocity Sensing
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Each hovercraft has 3 downward-looking cameras at different angles

• Connect to a Serial Peripheral Interface (SPI)
  • High-speed serial bus

• When you query a camera, it will tell you how many pixels of “slip” have happened since the last time you asked
  • Both X and Y components

• With two or more cameras, we can estimate how far the craft has moved in three dimensions
Component 1: Physical Interface

Common across all cameras:
- Black: Ground
- Red: +5V Power
- Blue: MISO (Arduino pin 12)
- Orange: MOSI (Arduino pin 11)
- Green: SCL (Arduino pin 13)
- Gray: Reset (choose an unused digital pin)

Each camera has a yellow select line (choose a unique, unused digital pin)
## Component 2: Supporting Types/Implementation

**Top of program:**

```c
// Promise that we will implement this function later
void camera_step();

// Create a task that will be executed once per 50 ms
PeriodicAction camera_task(50, camera_step);
```

**Loop:**

```c
void loop()
{
    // Check to see if it is time to execute camera_step()
    camera_task.step();
}
```
camera_step()

• This function is guaranteed to be called once per 50 ms
• For each call to this function:
  • Call accumulate_slip() to read the cameras and interpret the returned values
    void accumulate_slip(int32_t adx[3], int32_t ady[3])
  
• Once per second:
  • Print the accumulated slip values
• If the character ‘c’ is received from the laptop, then set all the slip values to zero
Component 3: Interface Function

Implement the function:

```c
void accumulate_slip(int32_t adx[3], int32_t ady[3])
```

- Queries each of the cameras
- If there is slip, then it adds the latest slip to the accumulated slip
Camera Interface

Top of program (example definitions):

// Global constants
// Total number of cameras
const int NUM_CAMERAS = 3;

// Select pins for the 3 cameras
const uint8_t CAMERA_SELECT[NUM_CAMERAS] = {8, 7, 10};

// Common reset pin
const uint8_t RESET_PIN = 9;

// Camera interface object
OpticalFlowCamera cameras(RESET_PIN);
accumulate_slip()

int8_t dx, dy;
uint8_t quality;
int result;

// For the ith camera:
result = cameras.readSlip(CAMERA_SELECT[i],
                          dx, dy, quality);

New behavior in C++ (not seen in C):
• readSlip() will change the value of the variables dx, dy
  and quality
readSlip

result = cameras.readSlip(CAMERA_SELECT[i],
                           dx, dy, quality);

• If result == 0:
  • dx, dy and quality variables have been changed and can be used
• If result == -1:
  • readSlip() is not being called quickly enough
• If result == -2:
  • No slip has occurred; do not use dx, dy and quality
Component 4: Data Collection

• Record 10 repetitions of the accumulated values for three types of movement: forward 1m, leftward 1m, rotate clockwise 360 degrees
• Store in a table: a total of 30 rows
Component 4: Sensor Model

- We are estimating the parameters of functions of the forms of:

\[ dX = a_1 \times adx_1 + a_2 \times ady_1 + a_3 \times adx_2 + a_4 \times ady_2 + a_5 \times adx_3 + a_6 \times ady_3 \]

- where \( a_1 \) ... \( a_6 \) are the coefficients of our function, and \( adx?/ady? \) are the accumulated slip values.
Sensor Model

Use “Multi-Regression” to compute the parameters

• Handle dX, dY and dtheta separately (one set of parameters for each)

• Use all 30 data points to fit each of the three parameter sets
Component 5: Implement the Model

Implement the function:

```c
void compute_chassis_motion(int32_t adx[3], int32_t ady[3],
                             float[3] motion);
```

Translate adx and ady into hovercraft motion
• Inputs: adx, ady
• Output: motion
Component 6: Testing

camera_step() changes:

• Once per second: compute and print motion

Take five more samples of each motion type: move forward 1m, move left 1m and turn 360 degrees

• For each of dX, dY and dtheta (separately): plot mean and variance for each motion type. A bar graph is good here (a box plot is even better)
Hints

• Start this project early
• Keep things simple