• Project 1: Catme survey
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();
void report_step();

// Create a task that will be executed once per 50 ms
PeriodicAction camera_task(50, camera_step);
PeriodicAction report_task(1000, report_step);
```

Loop:

```c
void loop()
{
    // Check to see if it is time to execute the tasks
    camera_task.step();
    report_task.step();
}
```
Global Variables

int32_t adx[3] = {0,0,0};
int32_t ady[3] = {0,0,0};
float cartesian_position[3] = {0.0, 0.0, 0.0};
camera_step()

- This function is guaranteed to be called once per 50 ms
- Query each camera for how much it has “slipped” since the last query
- Add this slip to adx/ady
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);
Reading Slip from One Camera

```c
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:

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

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

Use “Multi-Regression” to compute the parameters

• Handle X, Y and theta 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] cartesian_position);
```

Translate adx and ady into hovercraft motion

• Inputs: adx, ady
• Output: cartesian_position
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 X, Y and theta (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