As you arrive:

1. Start up your computer and plug it in.
2. ***Log into Angel*** and go to CSSE 120.
   Do the ***Attendance Widget*** –
   the PIN is on the board.
3. Go to the ***Course Schedule*** web page.
   Open the ***Slides*** for today if you wish.
4. Checkout today's project: `Session13_LoopPatternsForInput`

Session 13

Loop patterns for input, Max/min, Structure Charts

Loop Patterns for Input

Min-Max loop pattern

Wait-until-event loop pattern

Line Following!

Checkout today's project:

`Session13_LoopPatternsForInput`

Are you in the Pydev perspective? If not:

`Window ~ Open Perspective ~ Other` then `Pydev`

Messed up views? If so:

`Window ~ Reset Perspective`

Troubles getting today's project? If so:

No SVN repositories view (tab)? If it is not there:

`Window ~ Show View ~ Other`
then `SVN ~ SVN Repositories`

1. ***In your SVN repositories view (tab), expand your repository*** *(the top-level item) if not already expanded.*
   - If no repository, perhaps you are in the wrong Workspace. Get help.
2. ***Right-click on today's project****, then select* `Checkout`.
   Press ***OK*** *as needed.* The project shows up in the
   `Pydev Package Explorer`
   to the left. Expand and browse the modules under `src` as desired.

Recap: Two main types of loops

- ## Definite Loop
  - The program knows ***before the loop starts*** how many times the loop body will execute
  - Implemented in Python as a `for` loop. Typical patterns include:
    - Counting loop, perhaps in the Accumulator Loop pattern
    - Loop through a sequence directly
    - Loop through a sequence using indices
  - Cannot be an infinite loop
- ## Indefinite loop
  - The body executes as long as some condition is `True`
  - Implemented in Python as a `while` statement
  - Can be an infinite loop if the condition never becomes `False`
  - Python's `for line in file:` construct
    Indefinite loop that looks syntactically like a definite loop!

Recap: Definite Loops

- ***Definite loop***
  The program knows **_before the loop starts_** how many times the loop body will execute
  - ***Counted loop***
    Special case of definite loop where the sequence can be generated by `range()`
- Implemented in Python as a `for` loop
- Example to the right shows 3 typical patterns

Examples of ***definite loops*:**

- All three of these examples illustrate the Accumulator Loop pattern
- The first example is a ***counted*** loop
- The second and third examples are equivalent ways to loop through a sequence
  - Second example is NOT a counted loop
  - Third example IS a counted loop

```
sum = 0
for k in range(10):
    sum = sum + (k ** 3)

sum = 0
for number in listOfNumbers:
    sum = sum + number

sum = 0
for k in range(len(listOfNumbers)):
    sum = sum + listOfNumbers[k]
```

Recap: Indefinite Loops

- Number of iterations is *not known* when loop starts
- Is typically a conditional loop
  - Keeps iterating as long as a certain condition *remains* **True**
  - The conditions are ***Boolean expressions***
- Typically implemented using a **while** statement

```
sum = 0
for k in range(10):
    sum = sum + (k ** 3)
```

Definite loop

```
sum = 0
k = 0
while k < 10:
    sum = sum + (k ** 3)
    k = k + 1
```

Indefinite loop that computes the same sum as the definite loop

The *input-compute-in-a-loop* pattern

- We have seen the *input-compute-output* pattern:

```
get data
compute using the data
print the result
```

Input from the user or as a parameter

Or *return* the result

- A cousin of that pattern is the *input-compute-in-a-loop* pattern:

```
pre-loop computation
repeatedly:
        get data
        compute using the data
post-loop computation
```

We've seen a special case of this pattern: the ***Accumulator Loop*** pattern. Today we will examine other special cases.

Getting inputs (more than one) from the user

- Suppose that you want to get a bunch of numbers (or other data) from the user.
- Do you need a loop?
  If so, what will you do each time through the loop?
  - Answer: Yes. Get one number from the user each time through the loop.
- What are some different ways that you might use to let the program know when the user is finished entering numbers?
  - *Ask the user how many numbers* she wants to enter. Then loop that many times.
  - Each time through the loop, *ask the user "Are you done?"*.
    Exit the loop when she says "Yes."
  - The *user enters a special **sentinel*** value
    (e.g. a negative number) to indicate that she is done.
  - The *user enters nothing* (just an empty line) to indicate that she is done.

We'll now see examples of each of these approaches.

For loop pattern

pre-loop computation
for [amount of data] :
    get data
    compute using the data
post-loop computation

- Open the

    m1_input_by_user_count.py

  module and execute it together
- When does the loop terminate?
- Is this the best way to make the user enter input?
  - Why?
  - Why not?

This approach is a lousy way to get numbers that the user supplies, because:

The user has to count in advance how many numbers they will supply.

Interactive loop pattern

- One version: an ***interactive*** loop

```
pre-loop computation
while [there is more data]:
        get data
        compute using the data
post-loop computation
```

```
set a flag indicating that there is data
other pre-loop computation
while [there is more data]:
        get data
        compute using the data
        ask the user if there is more data
post-loop computation
```

Examine and run the ***m2_input_by_asking_if_more.py*** module in the project you checked out today.

This approach is also a lousy way to get numbers that the user supplies, because:

The user has to answer repeatedly the "more numbers?" question.

Sentinel loop pattern

- Better version: use a ***sentinel***

pre-loop computation
while [there is more data]:
    get data
    compute using the data
post-loop computation

get data
other pre-loop computation
while [data does not signal end-of-data]:
    compute using the data
    get data
post-loop computation

Examine and run the ***m3_input_using_sentinel.py*** module in the project you checked out today.

User signals end of data by a special ***"sentinel"*** value.

Note that the sentinel value is not used in calculations.

This approach (using negative numbers as the sentinel) has a flaw. What is that flaw?

Answer: You cannot have negative numbers included in the average!

Better sentinel loop pattern

- Best (?) version:
  use *no-input* as the ***sentinel***

```
pre-loop computation
while [there is more data]:
        get data
        compute using the data
post-loop computation
```

```
get data as a string
other pre-loop computation
while [data is not the empty string]:
        data = float(data)
        compute using the data
        get data as a string
post-loop computation
```

Examine and run the ***m4_input_using_better_sentinel.py*** module in the project you checked out today.

Above converts the data to a *float*, but other problems might do other conversions.

User ***signals*** end of data by pressing the ***Enter key*** in response to a *input*.

The ***sentinel*** value is again not used in calculations.

Loop-and-a-half pattern

- Use a ***break***

```
pre-loop computation
while True:
        get data
        if data signals end-of-data:
                break
        compute using the data
post-loop computation
```

```
pre-loop computation
while True:
        get data as a string
        if data == "":
                break
        data = float(data)
        compute using the data
post-loop computation
```

Examine and run the *m4_input_using_sentinel_in_loop_and_a_half* module in the project you checked out today.

The ***break*** statement exits the enclosing loop. Here we continue to use no-input as the sentinel.

This pattern is equivalent to the pattern on the preceding slide. Some prefer one style; others prefer the other. You may use whichever you choose.

Escaping from a loop

- **break** statement ends the loop immediately
  - Does not execute any remaining statements in loop body
- **continue** statement skips the rest of **this** iteration of the loop body
  - Immediately begins the **next** iteration (if there is one)
- **return** statement ends loop and function call
  - May be used with an expression
    - within body of a function that returns a value
  - Or without an expression
    - within body of a function that just does something

Summary of *input-compute-in-a-loop* patterns

- *For* loop, asking how many inputs
- *Interactive* loop, asking repeately "more inputs?"
- *Sentinel* loop using a *special value* as the sentinel
- *Sentinel* loop using *no-input* as the sentinel
- *Loop-and-a-half*
  - Combined with use of no-input as the sentinel

Coming up – another loop pattern:
- Wait-for-event loop

Next session – More loop patterns:
- Nested loops

Your turn: do TODO #1 and #2 in ***m6_input_loops_practice.py***

TODO #3 is for homework.

The Min-Max loop pattern

- Here is an example for finding the smallest number is a sequence of numbers.

```
def min_of_list(numbers):
    """Returns the smallest of the numbers in the given list."""
    smallest = numbers[0]
    for k in range(1, len(numbers)):
        if numbers[k] < smallest:
            smallest = numbers[k]

    return smallest
```

You can run this code in ***m7_min_max_example.py*** and see how it uses an ***oracle*** to do ***unit-testing***.

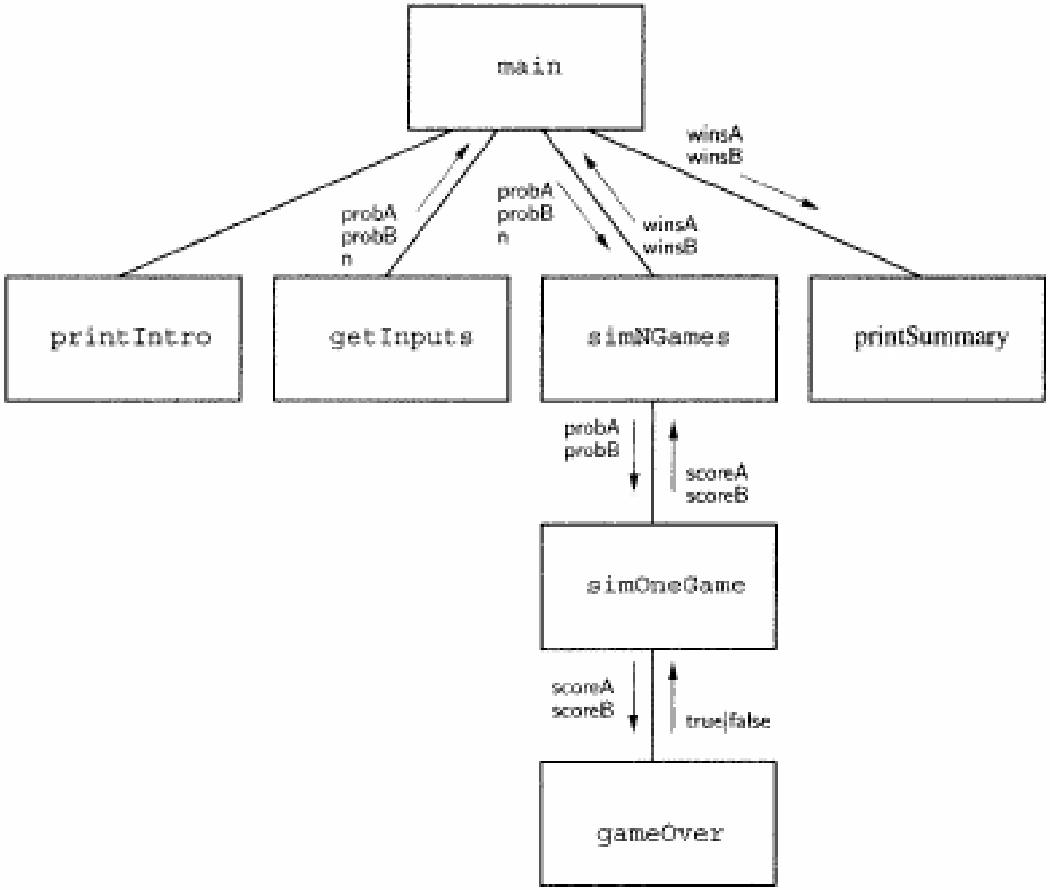
You'll apply this concept for homework.

Sometimes you want to know *where* in the list the smallest number is. In that case you would:

- Start **`minK`** at **0**
- When **`smallest`** changes, change **`minK`** to **`k`**

Structure charts

- What are they? A ***visual*** representation of:
  - Which functions use (call) which other functions
  - What parameters are sent to the called function
  - What values are returned by the called function
- Why use them?
  To help you design the structure of your program.

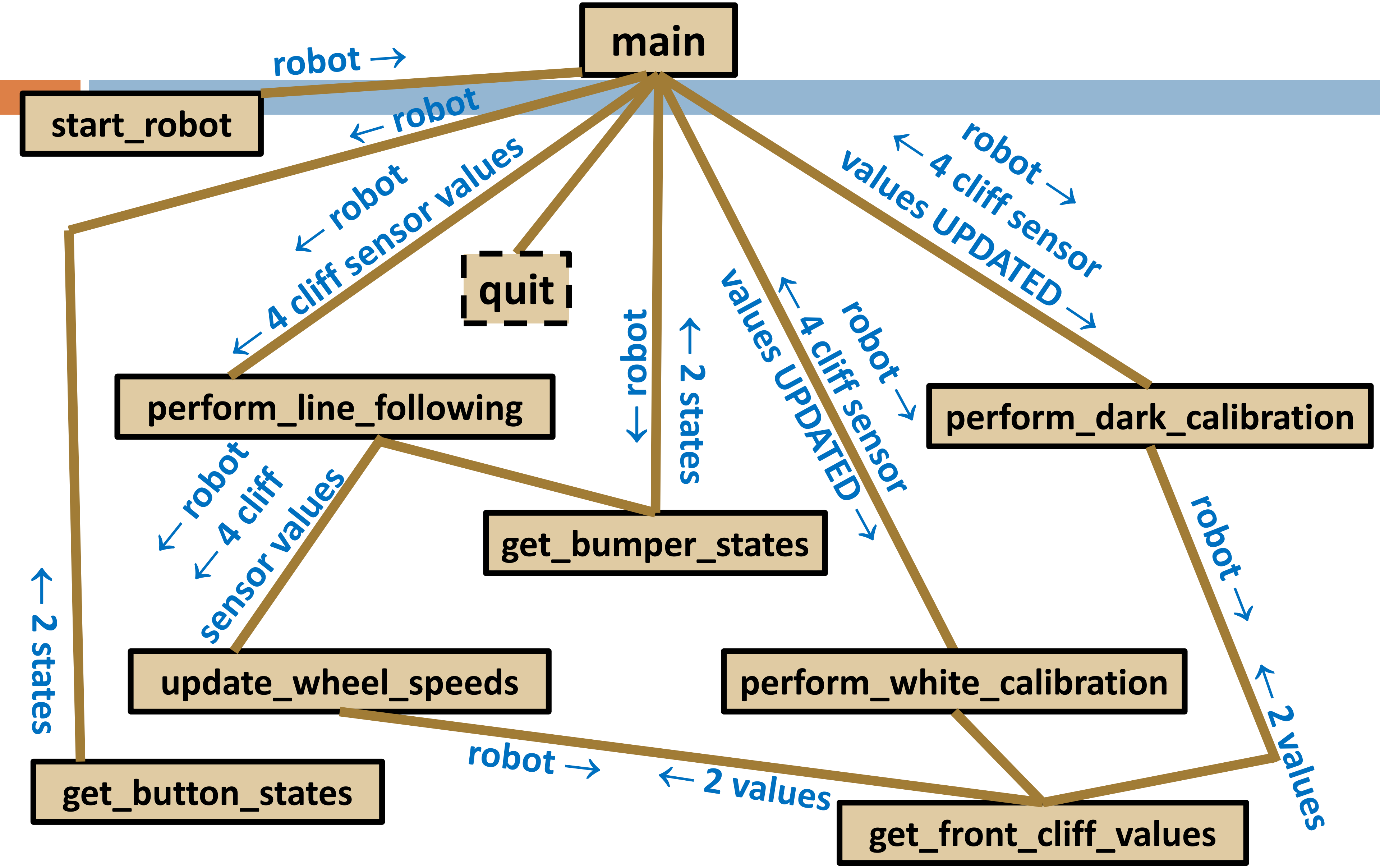


A structure chart for a *line-following* program

- Your boss wants a line-following program that works like this:
  - It starts the robot, putting it in FULL mode.
  - Then it enters a loop in which the user can press any of the following:
    - Play Button – the robot begins following the line (and stops when it bumps into anything).
    - Advance Button – the program shuts down the robot and exits.
    - Left Bumper – the program reads the two front cliff sensor values and saves them. The program expects that the user will have placed the robot on a WHITE surface just before pressing this bumper.
    - Right Bumper – the program again reads the two front cliff sensor values and saves them. But now the program expects that the user will have placed the robot on a BLACK surface just before pressing this bumper.

    When the robot does its line following, it uses the 2 pairs of cliff sensor readings for calibration.
- Together, let's design a structure chart for this program.
  - What functions should *main* call?
  - What functions should those functions call?
  - What parameters are sent and what values are returned by the calls?

Develop a ***structure chart*** for a ***line-following*** program



Line-following algorithms

- There are many algorithms for following lines, depending on how many and where your sensors are, along with other factors. Let's figure out a simple 2-sensor approach.
- First, what is the effect of different wheel speeds?
  - Left faster → veer right
    Right faster → veer left
- Now look at the situations to the right, starting at the bottom. What should the robot do in each situation?

Left light sensor sees *white* (light)
Right light sensor sees *black* (dark)
Action:
- Speed up the *left* wheel
- Slow down the *right* wheel
- So the robot veers right

Both light sensors see *white*
(the robot is straddling the line)
Action:
- Set wheel speeds equal
- So the robot goes straight ahead

Left light sensor sees *black* (dark)
Right light sensor sees *white* (light)
Action:
- Speed up the *right* wheel
- Slow down the *left* wheel
- So the robot veers left

Line-following algorithms

- If you speed up to a fixed, large amount, and slow down to a fixed, small amount, and ignore the middle case, that is called ***bang-bang control***.
- You could speed up the wheels *proportional* to how far from dark the sensor readings are:
  - So completely white by a sensor would speed up its wheel to 100% and completely black would slow it to 0% of its normal speed
  - Let W, D = completely white and dark. Let L be the current reading for the left sensor. What should the left motor speed be?

Left light sensor sees *white* (light)
Right light sensor sees *black* (dark)
Action:
- Speed up the *left* wheel
- Slow down the *right* wheel
- So the robot veers right

Both light sensors see *white*
(the robot is straddling the line)
Action:
- Set wheel speeds equal
- So the robot goes straight ahead

Left light sensor sees *black* (dark)
Right light sensor sees *white* (light)
Action:
- Speed up the *right* wheel
- Slow down the *left* wheel
- So the robot veers left

Line-following algorithms

- ***Proportional control:***
- Let W, D = completely white and dark. Let L be the current reading for the left sensor. What should the left motor speed be?

White numbers are large and black are small (near 0).

- Answer:

  p = (L – D) / (W – D)

  speed = p * some_constant

  But add to speed to give it a minimum speed, and clip it at a maximum speed.
- Similarly for the right wheel

Left light sensor sees *white* (light)
Right light sensor sees *black* (dark)
Action:

- Speed up the *left* wheel
- Slow down the *right* wheel
- So the robot veers right

Both light sensors see *white*
(the robot is straddling the line)
Action:

- Set wheel speeds equal
- So the robot goes straight ahead

Left light sensor sees *black* (dark)
Right light sensor sees *white* (light)
Action:

- Speed up the *right* wheel
- Slow down the *left* wheel
- So the robot veers left

Rest of Session

- ***With your instructor, discuss how to do line following.***
- ***Work on m9_line_follower.py***
  - Ask questions as needed!
- **Sources of help after class:**

  ```
  CSSE lab: Moench F-217
  7 to 9 p.m.
  Sundays thru Thursdays
  ```

  - **Assistants in the CSSE lab**
    - And other times as well (see link on the course home page)
  - **Email** `csse120-staff@rose-hulman.edu`
    - You get faster response from the above than from just your instructor