

Basic Python and Particle Filter

Nantawat Pinkam

I649E Wireless Sensor Networks

July 4, 2018




I649E WIRELESS SENSOR NETWORKS

<https://github.com/i649e/wsn-lab>

I649E's Github

<https://github.com/i649e/wsn-lab>

 **i649e** / **wsn-lab** Watch 0 Star 0 Fork 0


[Code](#) [Issues 0](#) [Pull requests 0](#) [Projects 0](#) [Wiki](#) [Insights](#) [Settings](#)




No description, website, or topics provided. [Edit](#)

[Add topics](#)

[9 commits](#) [1 branch](#) [0 releases](#) [2 contributors](#)

Branch: master [New pull request](#) [Create new file](#) [Upload files](#) [Find file](#) [Clone or download](#)

 **i649e** change guide Latest commit d61ffe8 3 minutes ago

 Project	add example	14 days ago
 Chapter_06_Raspberry_Pi_3_Model_B_Getting_Started_Guide.pdf	change guide	3 minutes ago
 README.md	Update README.md	14 days ago



Python Installation

<https://www.python.org/downloads/>

The screenshot shows the Python.org website with a dark blue header. The Python logo is on the left, and a search bar with a magnifying glass icon and a 'GO' button is on the right. Below the header is a navigation bar with links: About, Downloads, Documentation, Community, Success Stories, News, and Events. The main content area has a dark blue background with a yellow and white striped parachute carrying a cardboard box. The text 'Download the latest version for Mac OS X' is prominently displayed in yellow. Below this is a yellow button labeled 'Download Python 3.7.0'. Further down, there are links for 'Python for Windows, Linux/UNIX, Mac OS X, Other' and 'Pre-releases'. At the bottom, there is a link for 'Looking for Python 2.7? See below for specific releases'.

python™

Search GO Socialize

About Downloads Documentation Community Success Stories News Events

Download the latest version for Mac OS X

Download Python 3.7.0

Looking for Python with a different OS? Python for [Windows](#),
[Linux/UNIX](#), [Mac OS X](#), [Other](#)

Want to help test development versions of Python? [Pre-releases](#)

Looking for Python 2.7? See below for specific releases



I649E WIRELESS SENSOR NETWORKS

<https://github.com/i649e/wsn-lab>

Python References

<https://github.com/i649e/wsn-lab/tree/master/Reference>

<https://www.learnpython.org>

 learnpython.org

[Python](#) [Java](#) [HTML & CSS](#) [Go](#) [C](#) [C++](#) [JavaScript](#) [PHP](#) [Shell](#) [C#](#) [Perl](#) [Ruby](#) [Jobs](#)

 Like 10K

 Tweet

 G+

 Share

14.3K

This site generously supported by [DataCamp](#). DataCamp offers online interactive [Python Tutorials](#) for Data Science. Join **575,000** other learners and get started learning Python for data science today!

Welcome

Welcome to the LearnPython.org interactive Python tutorial.



Python Module Installation

In command prompt (Windows) or Terminal (macOS/Linux)

Python 2

```
python -m pip install --upgrade pip  
python -m pip install <module name>
```

Python 3

```
python3 -m pip install --upgrade pip  
python3 -m pip install <module name>
```



Basic Python

- Mostly same as C, C#, C++
- Operators
 - `=, +, -, *, /`
 - `//` (integer divide), `%` (modulation), `**` (a^b)
- Boolean
 - `>, <, >=, <=, ==, !=`
 - `and, or`
- Variable Assignment
 - `A=B`
 - `A=B=1`
 - `A,B,C = 1,2,3 → A=1; B=2; C=3`
 - `A+=1. → A=A+1`
- Print value
 - `print(A)`
 - `print("A+B = " + str(2))`

(The contents in print must be the same type)



Basic Python

- Container

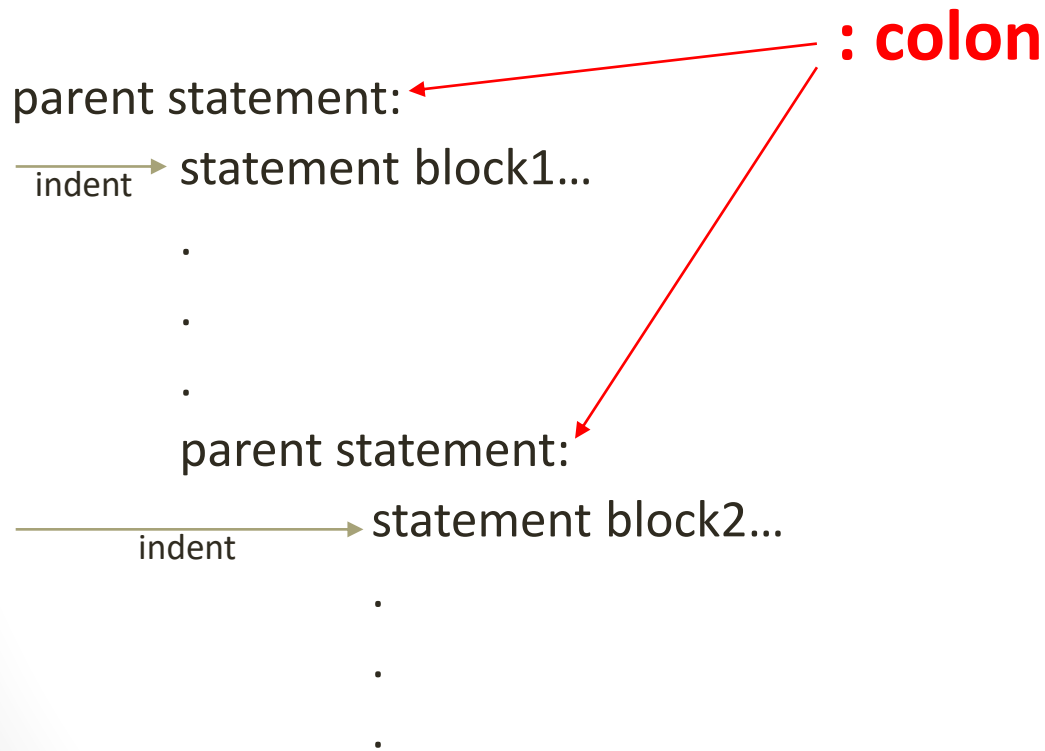
- List: `A=[1, "apple", 3]` (can be added more variables later)
 - `A.append(x)`, `A.extend(x)`, `A.insert(i, x)`, `A.remove(x)`, `A.pop([i])`, `A.clear()`, `A.count(x)`, `A.reverse()`, `A.copy()`
- Tuple: `A=(1, "apple", 3)` (cannot be changed)
- Dictionary: `A={key:value, 1: "apple"}`
 - `A.get(key)`, `A.has_key(key)`, `A.items()`, `A.keys()`, `A.update(B)`, `A.value()`
- Set: `A={key1, key2, "apple"}`

- Useful commands

- `len(A)` Number of elements in A
- `A[-1]`, `A[0]`, `A[1]`, `A[-1:1]` Support positive and negative indexes



Statement Blocks



Loop and Function

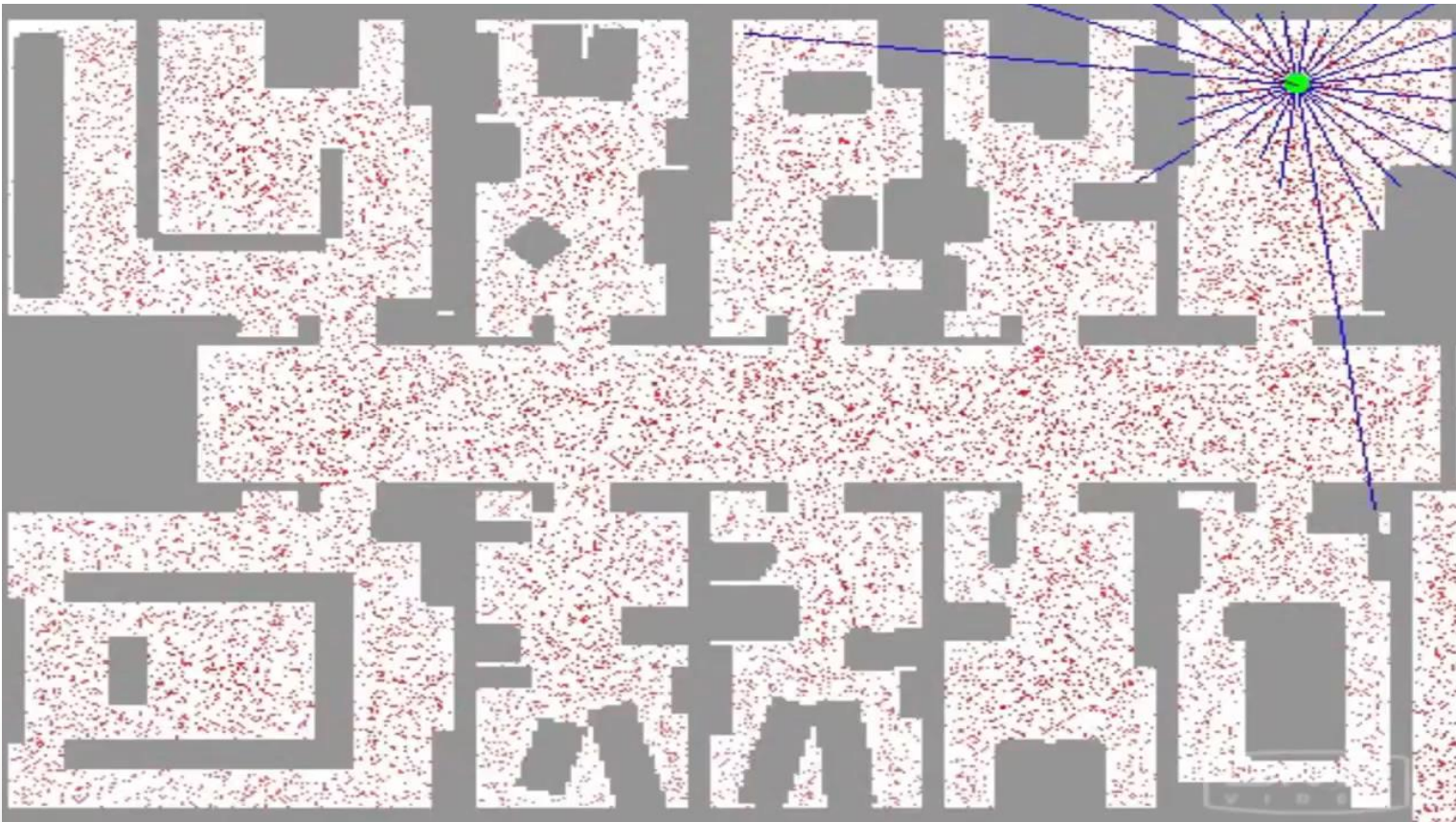
range(x)

0, 1, 2, ..., x-1

Python	C
<pre>for i in range(5): print(i)</pre>	<pre>for (i = 0; i < 5; i++){ printf("%d\n", i); }</pre>
<pre>i=0 while(i < 5): print(i) i+=1</pre>	<pre>int i=0; while(i < 5){ printf("%d\n",i); i++; }</pre>
<pre>def A_plus_B (A, B): return A+B A, B = 1, 2 AB = A_plus_B(A, B) print(AB)</pre>	<pre>int A_plus_B(int A, int B){ return A+B; } int main(){ int A=1;int B=2;int AB; AB = A_plus_B(A,B); printf("%d\n",AB); return 0; }</pre>



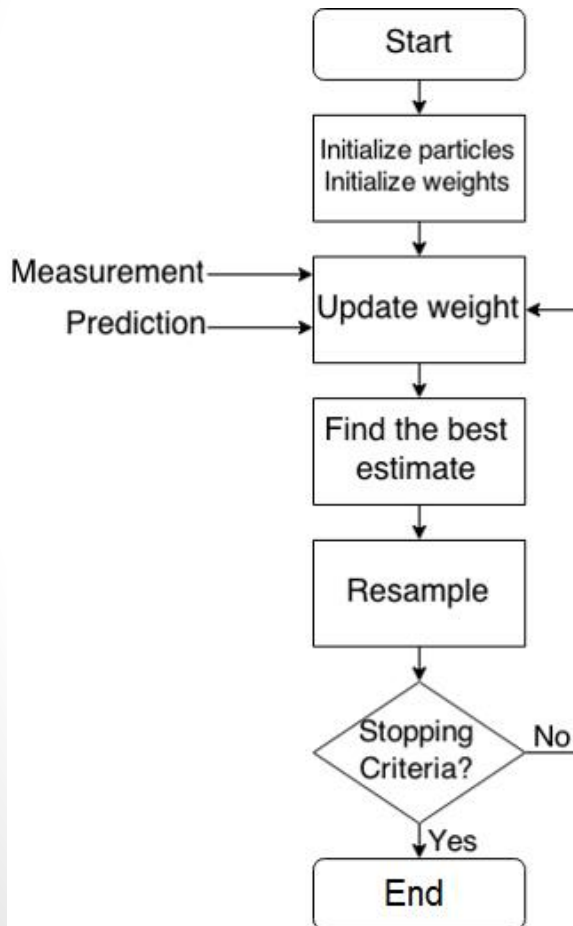
Sample-based Localization



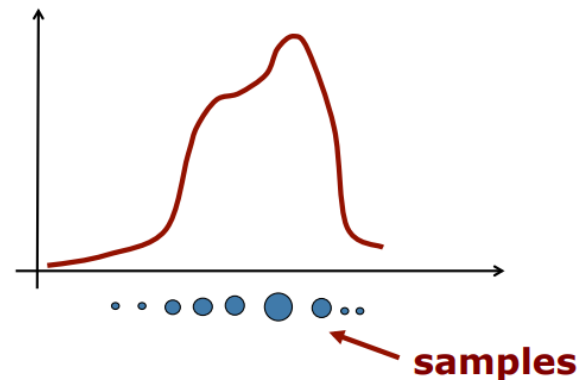


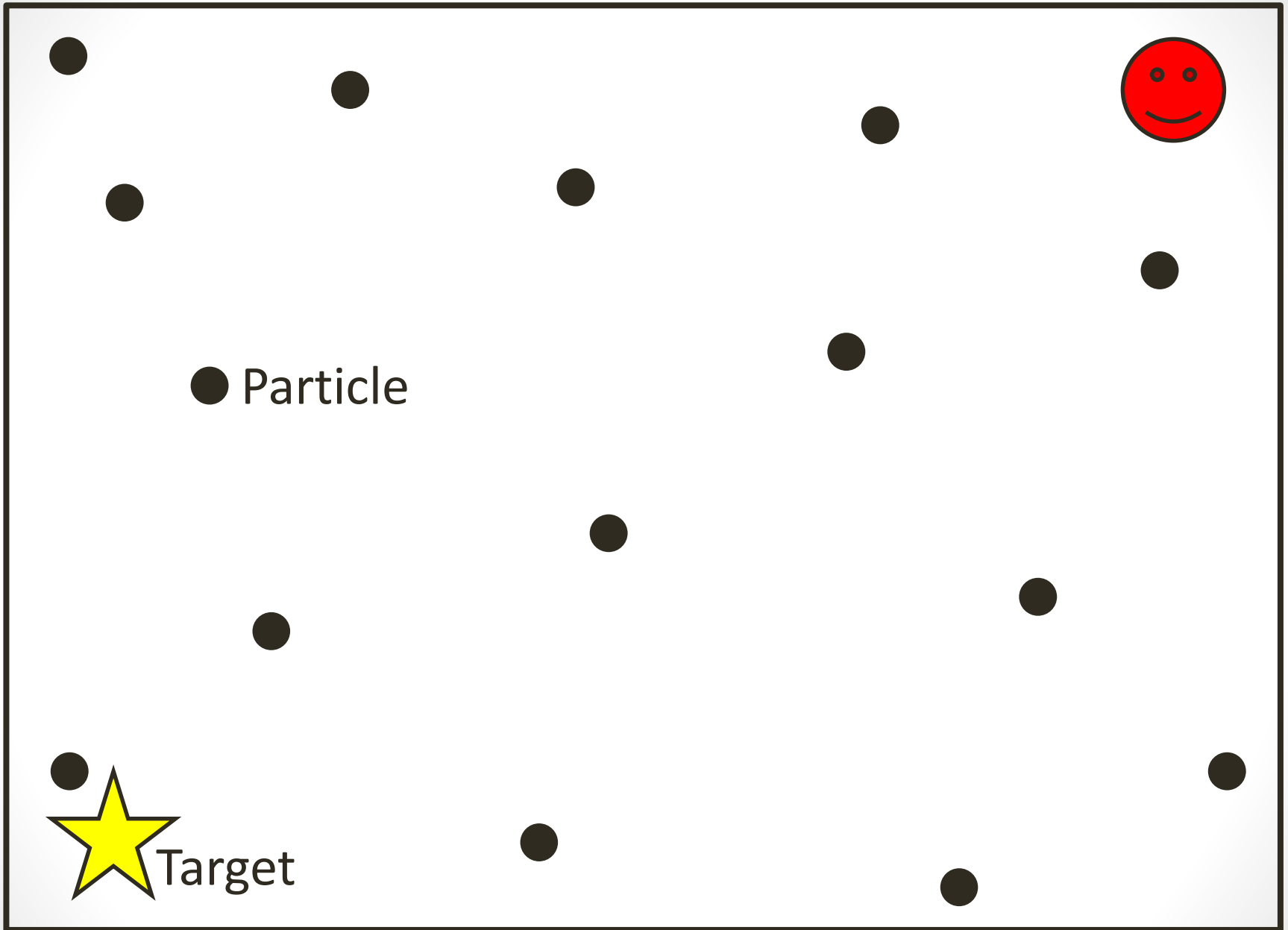
Particle Filter

$$P(x | z_1, \dots, z_n) = \frac{\overset{\text{Measurement model}}{P(z_n | x, z_1, \dots, z_{n-1})} \overset{\text{Prior Probability}}{P(x | z_1, \dots, z_{n-1})}}{\underset{\text{Normalization}}{P(z_n | z_1, \dots, z_{n-1})}}$$

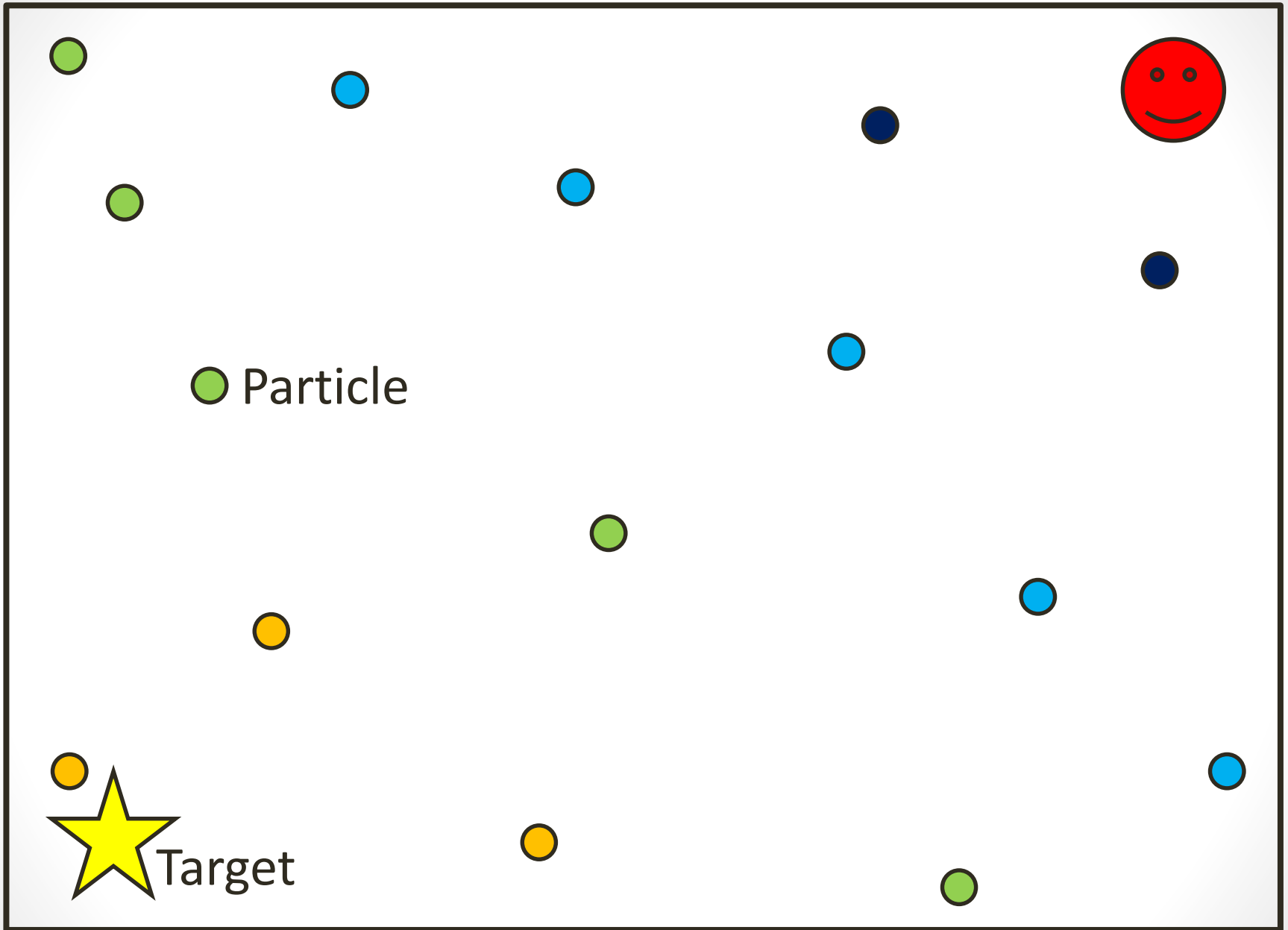


- Bayesian based filter that sample the whole workspace by a weight function derived from the belief distribution of previous stage.
- Represent belief by random samples. (e.g. each particle is the hypothesis of the target state)

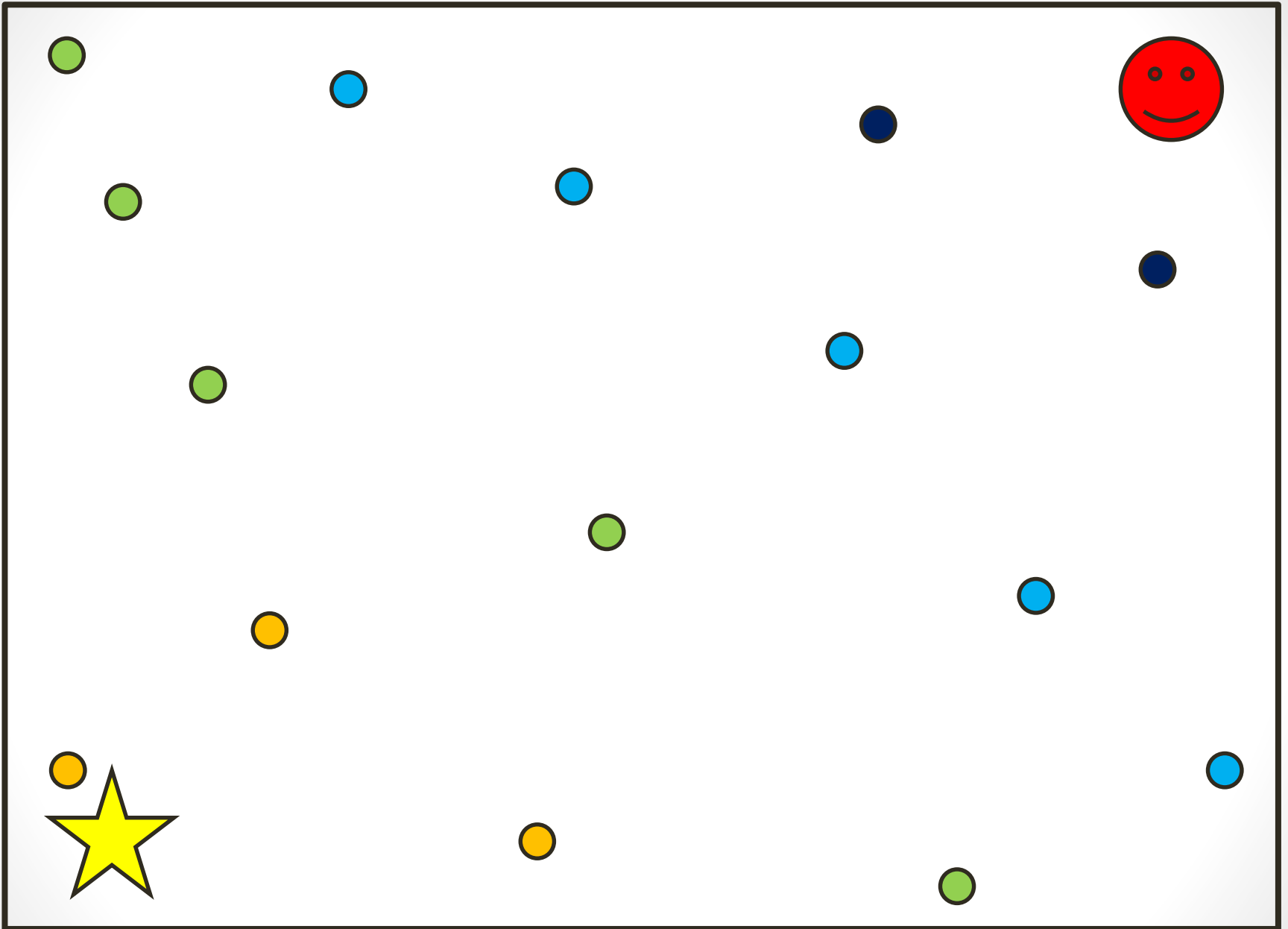




1 Randomly place particle all over the workspace.



2 Calculate the weight of each particle



3 Find the best estimate and resample the low weight particles [14]



Best Estimate



Target

Repeat 2-3 (calculate weight > best estimate > resample)



Random Samples as Particles



$$\mathcal{X} = \left\{ \left\langle \underset{\substack{\uparrow \\ \text{state} \\ \text{hypothesis}}}{x^{[i]}}, w^{[i]} \right\rangle \right\}_{i=1, \dots, N}$$

**state
hypothesis**

**importance
weight**

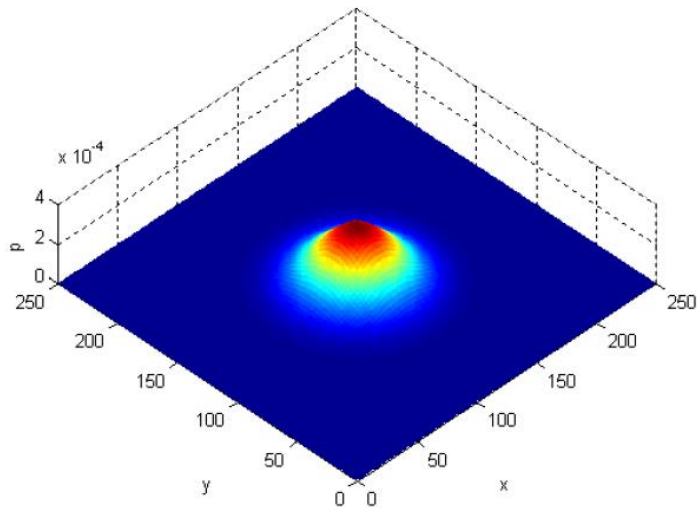
Example:

- Location (x, y, z)
- Measurement

How much should I trust
this particle?



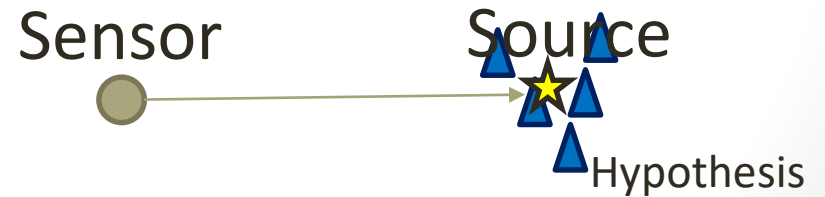
Belief Space



Gaussian belief space

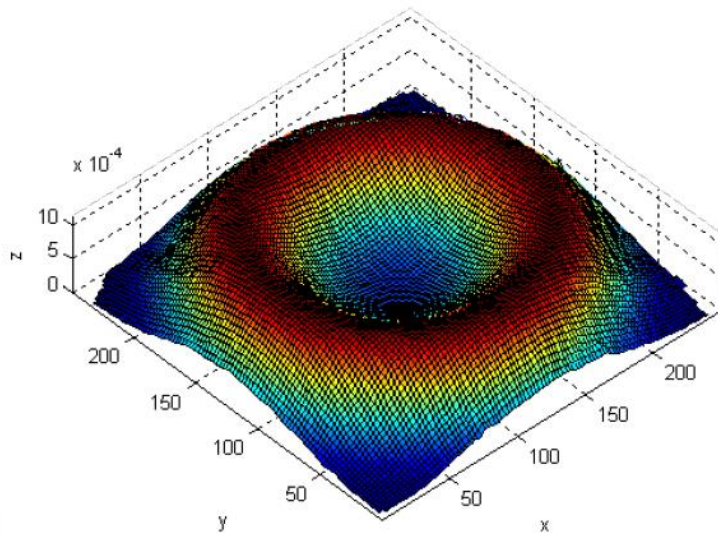
Example

- Measurements from a sensor with **known** direction to the source.





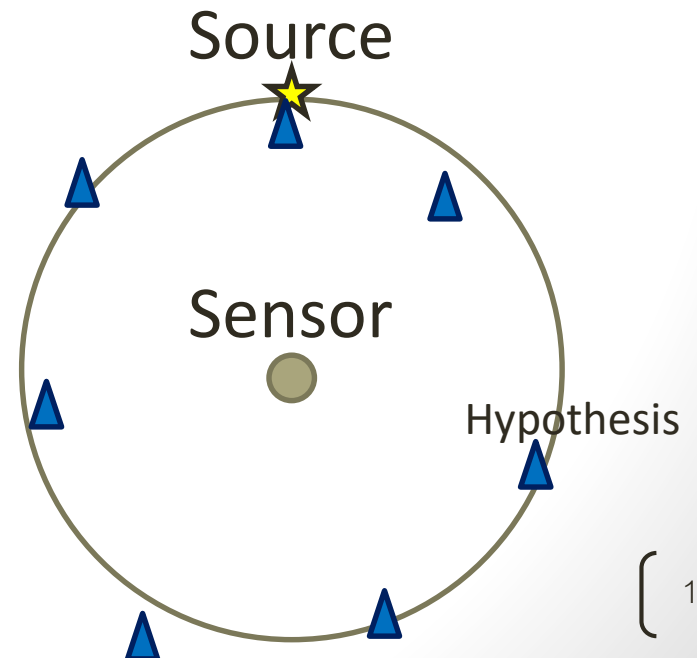
Belief Space



Non-Gaussian belief space

Example

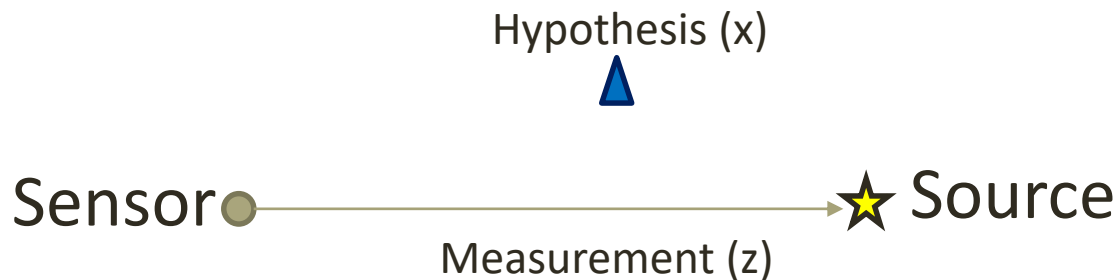
- Measurements from a static sensor with **unknown** direction to the source.





Particle Weight

- By using likelihood function to determine the weight.
- Basically, we compare the hypothesis with the measurement and calculate the weight.



$$\text{Weight} = N(x|z, \sigma^2)$$

N = normal distribution



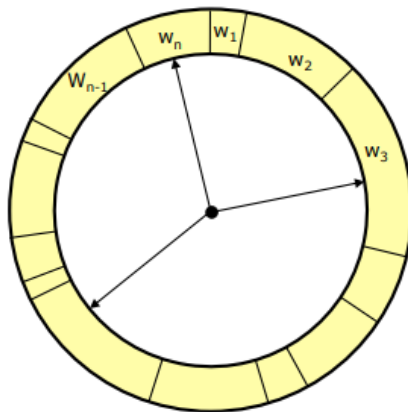
Estimation

- Estimate the most likely state from all/some particles.
- Method of estimation: weight average, mean, top particles, etc.
- Particle filter can run with finite iterations or until the criteria are met. (e.g. no more particles improvement)

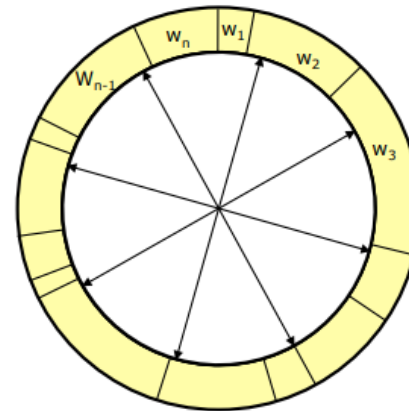


Resample

- Survival of the fittest: Replace unlikely samples by more likely ones
- Avoid many samples cover unlikely states
- Needed as we have a limited number of samples



▪ Roulette wheel



▪ Stochastic universal sampling



Demo: 1D Particle Filter

Requirements: need to install python modules and jupyter notebook

```
python3 -m pip install numpy scipy matplotlib jupyter
```

Download Tutorial 2 1D Particle Filter.ipynb from Github

In Command prompt/Terminal, cd to your downloaded file directory then type:

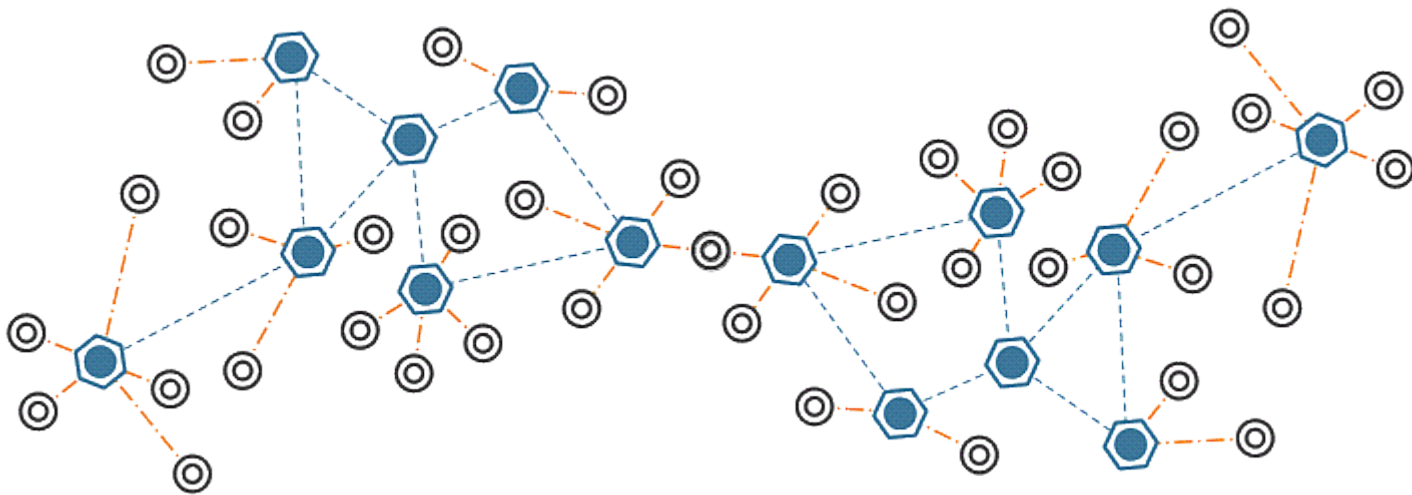
```
jupyter notebook
```

Open Tutorial 2 1D Particle Filter.ipynb from jupyter notebook

You also can run 1D_pf.py from the class Github.



Question and Answer



THANK YOU.