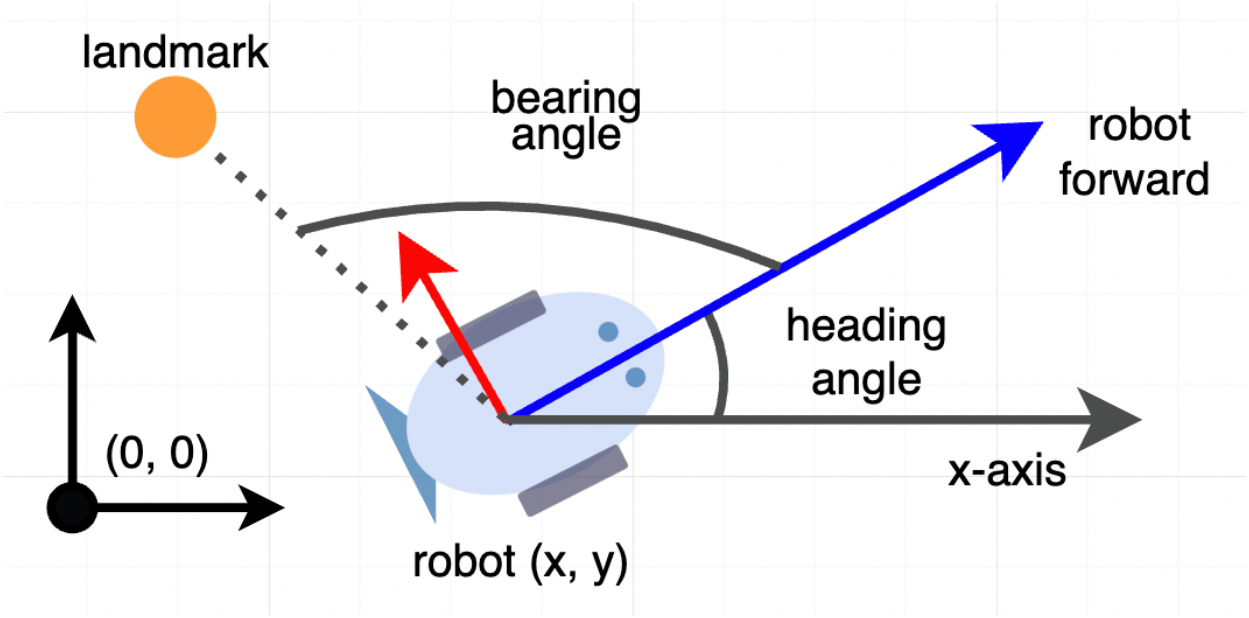
Symforce Tutorial

Notebook ini adalah tutorial untuk menggunakan Symforce. Tutorial ini akan membahas tentang:

- Instalasi Symforce menggunakan pip via bash command
- Contoh sederhana pemodelan dan penyelesaian masalah pengoptimalan dengan SymForce. Dalam contoh ini robot bergerak melalui bidang 2D dan tujuannya adalah untuk memperkirakan posenya pada beberapa langkah waktu dengan pengukuran kebisingan.



Instalasi Symforce menggunakan pip via bash command

Note : tested menggunakan Github Codespace dengan Ubuntu 20.04

In [26]:
```
%%bash
pip install symforce
```

```
Requirement already satisfied: symforce in /usr/local/python/3.10.4/lib/
python3.10/site-packages (0.7.0)
Requirement already satisfied: skymarshal==0.7.0 in /usr/local/python/3.10.4/lib/
python3.10/site-packages (from symforce) (0.7.0)
Requirement already satisfied: jinja2 in /home/codespace/.local/lib/python3.10/
site-packages (from symforce) (3.1.2)
Requirement already satisfied: numpy in /home/codespace/.local/lib/python3.10/
site-packages (from symforce) (1.23.4)
Requirement already satisfied: black in /usr/local/python/3.10.4/lib/python3.10/
site-packages (from symforce) (22.10.0)
Requirement already satisfied: graphviz in /usr/local/python/3.10.4/lib/
python3.10/site-packages (from symforce) (0.20.1)
Requirement already satisfied: clang-format in /usr/local/python/3.10.4/lib/
python3.10/site-packages (from symforce) (15.0.4)
Requirement already satisfied: sympy~=1.11.1 in /usr/local/python/3.10.4/lib/
python3.10/site-packages (from symforce) (1.11.1)
Requirement already satisfied: scipy in /home/codespace/.local/lib/python3.10/
site-packages (from symforce) (1.9.3)
Requirement already satisfied: symforce-sym==0.7.0 in /usr/local/python/3.10.4/
lib/python3.10/site-packages (from symforce) (0.7.0)
Requirement already satisfied: argh in /usr/local/python/3.10.4/lib/python3.10/
site-packages (from skymarshal==0.7.0->symforce) (0.26.2)
Requirement already satisfied: ply in /usr/local/python/3.10.4/lib/python3.10/
site-packages (from skymarshal==0.7.0->symforce) (3.11)
Requirement already satisfied: six in /home/codespace/.local/lib/python3.10/site-
packages (from skymarshal==0.7.0->symforce) (1.16.0)
Requirement already satisfied: mpmath>=0.19 in /usr/local/python/3.10.4/lib/
python3.10/site-packages (from sympy~=1.11.1->symforce) (1.2.1)
Requirement already satisfied: pathspec>=0.9.0 in /usr/local/python/3.10.4/lib/
python3.10/site-packages (from black->symforce) (0.10.2)
Requirement already satisfied: platformdirs>=2 in /home/codespace/.local/lib/
python3.10/site-packages (from black->symforce) (2.5.4)
Requirement already satisfied: mypy-extensions>=0.4.3 in /usr/local/python/
3.10.4/lib/python3.10/site-packages (from black->symforce) (0.4.3)
Requirement already satisfied: click>=8.0.0 in /usr/local/python/3.10.4/lib/
python3.10/site-packages (from black->symforce) (8.1.3)
Requirement already satisfied: tomli>=1.1.0 in /home/codespace/.local/lib/
python3.10/site-packages (from black->symforce) (2.0.1)
Requirement already satisfied: MarkupSafe>=2.0 in /home/codespace/.local/lib/
python3.10/site-packages (from jinja2->symforce) (2.1.1)
```

In [1]:
```
import symforce
symforce.set_epsilon_to_symbol()
```

In [2]:
```
import symforce.symbolic as sym
import numpy as np
```

In [3]:
```
pose =sym.Pose2(
    t=sym.V2.symbolic('t'),
    R=sym.Rot2.symbolic('R')
)
landmark= sym.V2.symbolic('L')
```

In [4]:
```
landmark_body=pose.inverse() * landmark
```

In [5]:
```
landmark_body.jacobian(pose)
```

```
[-L0*R_im + L1*R_re + t0*R_im - t1*R_re, -R_re, -R_im]
[-L0*R_re - L1*R_im + t0*R_re + t1*R_im, R_im, -R_re]
```

In [6]:
```
sym.atan2(landmark_body[0], landmark_body[1])
```

Out[6]:
```
atan2(L0*R_re + L1*R_im - (t0*R_re + t1*R_im), -L0*R_im + L1*R_re + (0.5
+ sign(-L0*R_im + L1*R_re - (-t0*R_im + t1*R_re)))*epsilon - (-t0*R_im +
t1*R_re))
```

In [7]:
```
sym.V3.symbolic('x').norm(epsilon=sym.epsilon())
```

Out[7]:
```
sqrt(epsilon + x0**2 + x1**2 + x2**2)
```

In [10]:
```
import symforce
try :
    symforce.set_epsilon_to_symbol()
except:
    pass
```

Keterangan

In [11]:
```
from symforce.values import Values
```

In [12]:
```
num_poses=3
num_landmarks=3
```

In [13…
```
initial_values=Values(
    poses=[sym.Pose2.identity()] * num_poses,
    landmarks=[sym.V2(-2, 2), sym.V2(1, -3), sym.V2(5, 2)],
    distances=[1.7, 1.4],
    angles=np.deg2rad([[145, 335, 55], [185, 310, 70], [215, 310, 70]]).to
    epsilon=sym.numeric_epsilon,
)
```

In [14…
```
def bearing_residual(
    pose: sym.Pose2, landmark: sym.V2, angle: sym.Scalar, epsilon: sym.Sca
) -> sym.V1:
    t_body = pose.inverse() * landmark
    predicted_angle = sym.atan2(t_body[1], t_body[0], epsilon=epsilon)
    return sym.V1(sym.wrap_angle(predicted_angle - angle))
```

In [15…
```
def odometry_residual(
    pose_a: sym.Pose2, pose_b: sym.Pose2, dist: sym.Scalar, epsilon: sym.S
) -> sym.V1:
    return sym.V1((pose_b.t - pose_a.t).norm(epsilon=epsilon) - dist)
```

In [1…

```python
from symforce.opt.factor import Factor

factors = []

# Bearing factors
for i in range(num_poses):
    for j in range(num_landmarks):
        factors.append(Factor(
            residual=bearing_residual,
            keys=[f"poses[{i}]", f"landmarks[{j}]", f"angles[{i}][{j}]", "e
        ))

# Odometry factors
for i in range(num_poses - 1):
    factors.append(Factor(
        residual=odometry_residual,
        keys=[f"poses[{i}]", f"poses[{i + 1}]", f"distances[{i}]", "epsilor
    ))
import warnings
warnings.filterwarnings("ignore")
```

In [17…

```python
from symforce.opt.optimizer import Optimizer

optimizer = Optimizer(
    factors=factors,
    optimized_keys=[f"poses[{i}]" for i in range(num_poses)],
    # So that we save more information about each iteration, to visualize
    debug_stats=True,
)
```

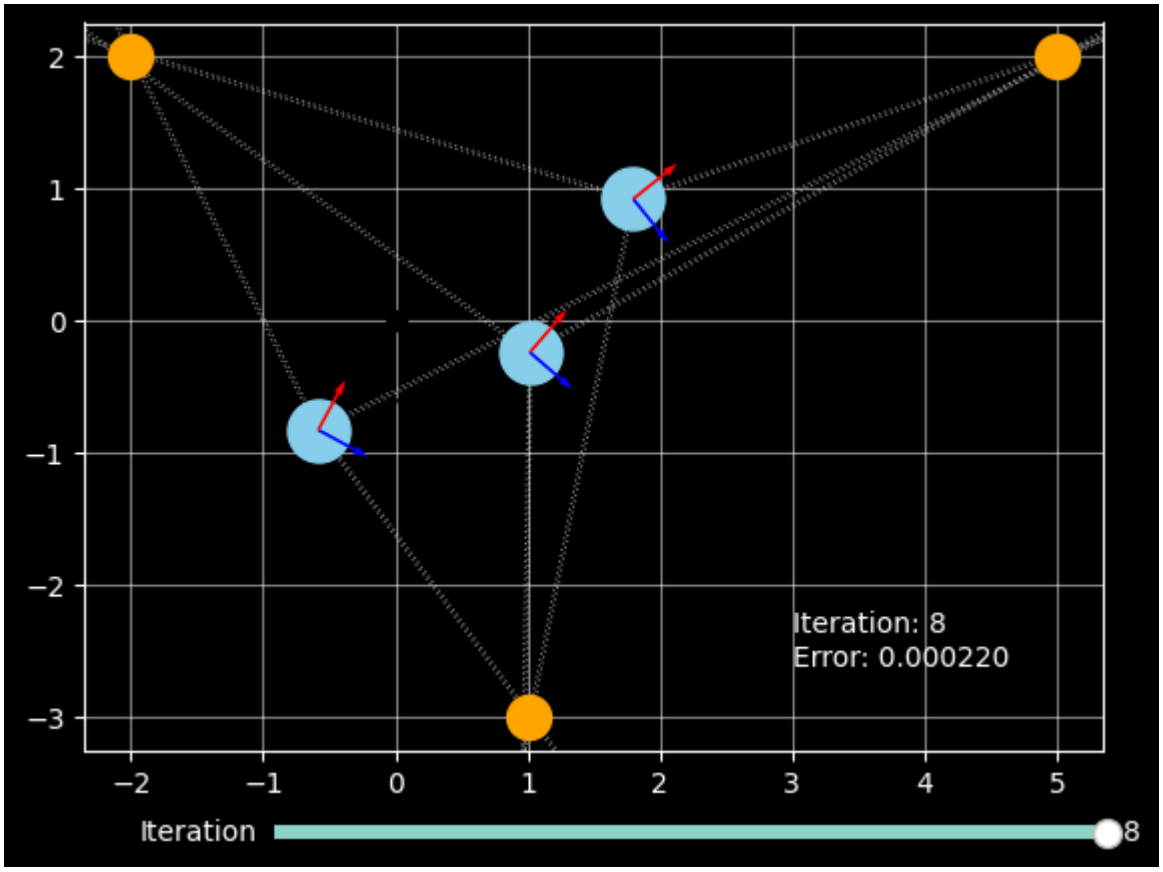
In [18]:

```python
result = optimizer.optimize(initial_values)
```

```
[2022-12-03 10:13:12.447] [info] LM<sym::Optimize> [iter    0] lambda:
1.000e+00, error prev/linear/new: 5.143/2.872/2.203, rel reduction: 0.57166
[2022-12-03 10:13:12.448] [info] LM<sym::Optimize> [iter    1] lambda:
2.500e-01, error prev/linear/new: 2.203/0.087/0.074, rel reduction: 0.96655
[2022-12-03 10:13:12.449] [info] LM<sym::Optimize> [iter    2] lambda:
6.250e-02, error prev/linear/new: 0.074/0.006/0.006, rel reduction: 0.91401
[2022-12-03 10:13:12.449] [info] LM<sym::Optimize> [iter    3] lambda:
1.562e-02, error prev/linear/new: 0.006/0.001/0.001, rel reduction: 0.90323
[2022-12-03 10:13:12.450] [info] LM<sym::Optimize> [iter    4] lambda:
3.906e-03, error prev/linear/new: 0.001/0.000/0.000, rel reduction: 0.60930
[2022-12-03 10:13:12.450] [info] LM<sym::Optimize> [iter    5] lambda:
9.766e-04, error prev/linear/new: 0.000/0.000/0.000, rel reduction: 0.08144
[2022-12-03 10:13:12.451] [info] LM<sym::Optimize> [iter    6] lambda:
2.441e-04, error prev/linear/new: 0.000/0.000/0.000, rel reduction: 0.00012
[2022-12-03 10:13:12.453] [info] LM<sym::Optimize> [iter    7] lambda:
6.104e-05, error prev/linear/new: 0.000/0.000/0.000, rel reduction: 0.00000
```

In [19…

```python
from symforce.examples.robot_2d_localization.plotting import plot_solutior
plot_solution(optimizer, result)
```



Generate C++ Code

Untuk setiap faktor, SymForce mengintrospeksi bentuk fungsi simbolik, melewati input simbolik untuk membuat ekspresi output, secara otomatis menghitung jacobian dari ekspresi output tersebut dengan variabel yang dioptimalkan, dan menghasilkan kode runtime cepat untuk variabel tersebut. Class Codegen adalah alat utama untuk menghasilkan kode runtime dari ekspresi simbolik. Dalam hal ini, kami meneruskan fungsi residual_bearing dan mengonfigurasinya untuk menghasilkan kode C++:

In [20]:
```
from symforce.codegen import Codegen, CppConfig

codegen = Codegen.function(bearing_residual, config=CppConfig())
```

In [21]:
```
codegen_linearization = codegen.with_linearization(
    which_args=["pose"]
)
import warnings
warnings.filterwarnings("ignore")
```

In [22]:
```
metadata = codegen_linearization.generate_function()
# with open('coba.cpp', 'w') as f:
#     f.write(metadata.generated_files[0])
#     f.close()
# with open(metadata.generated_files[0]).read() as f:
#     lines = f.readlines()
#     lines = [l for l in lines if "ROW" in l]
#     with open("out.txt", "w") as f1:
#         f1.writelines(lines)
# print(type(metadata.generated_files[0]))
code=open(metadata.generated_files[0]).read()
with open('coba.cpp', 'w') as f:
    f.write(code)
# print(open(metadata.generated_files[0]).read())
```

In [2…
```
%%bash
wget https://raw.githubusercontent.com/symforce-org/symforce/main/gen/cpp/sy
```

```
--2022-12-03 10:13:14--  https://raw.githubusercontent.com/symforce-org/symforce/
main/gen/cpp/sym/pose2.h
Resolving raw.githubusercontent.com (raw.githubusercontent.com)...
185.199.111.133, 185.199.108.133, 185.199.109.133, ...
Connecting to raw.githubusercontent.com (raw.githubusercontent.com)|
185.199.111.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 8015 (7.8K) [text/plain]
Saving to: ‘./sym/pose2.h.1’

     0K .......                                               100% 62.3M=0s

2022-12-03 10:13:14 (62.3 MB/s) - ‘./sym/pose2.h.1’ saved [8015/8015]
```