1. Install Symforce

```
In [1]: %%bash
        pip install symforce
```

```
Collecting symforce
  Downloading symforce-0.7.0-cp310-cp310-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (4.3 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 4.3/4.3 MB 29.8 MB/s eta 0:00:00
Collecting sympy~=1.11.1
  Downloading sympy-1.11.1-py3-none-any.whl (6.5 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 6.5/6.5 MB 35.2 MB/s eta 0:00:00
Collecting clang-format
  Downloading clang_format-15.0.4-py2.py3-none-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.5 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.5/1.5 MB 23.7 MB/s eta 0:00:00
Collecting symforce-sym==0.7.0
  Downloading symforce_sym-0.7.0-py3-none-any.whl (70 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 70.6/70.6 kB 3.6 MB/s eta 0:00:00
Requirement already satisfied: scipy in /home/codespace/.local/lib/python3.10/
site-packages (from symforce) (1.9.3)
Collecting black
  Downloading black-22.10.0-cp310-cp310-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.5 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.5/1.5 MB 29.6 MB/s eta 0:00:00
Requirement already satisfied: numpy in /home/codespace/.local/lib/python3.10/
site-packages (from symforce) (1.23.5)
Collecting skymarshal==0.7.0
  Downloading skymarshal-0.7.0-py3-none-any.whl (82 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 82.4/82.4 kB 4.0 MB/s eta 0:00:00
Requirement already satisfied: jinja2 in /home/codespace/.local/lib/python3.10/
site-packages (from symforce) (3.1.2)
Collecting graphviz
  Downloading graphviz-0.20.1-py3-none-any.whl (47 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 47.0/47.0 kB 2.1 MB/s eta 0:00:00
Requirement already satisfied: six in /home/codespace/.local/lib/python3.10/site-
packages (from skymarshal==0.7.0->symforce) (1.16.0)
Collecting ply
  Downloading ply-3.11-py2.py3-none-any.whl (49 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 49.6/49.6 kB 2.4 MB/s eta 0:00:00
Collecting argh
  Downloading argh-0.26.2-py2.py3-none-any.whl (30 kB)
Collecting mpmath>=0.19
  Downloading mpmath-1.2.1-py3-none-any.whl (532 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 532.6/532.6 kB 15.6 MB/s eta 0:00:00
Collecting mypy-extensions>=0.4.3
  Downloading mypy_extensions-0.4.3-py2.py3-none-any.whl (4.5 kB)
Requirement already satisfied: tomli>=1.1.0 in /home/codespace/.local/lib/
python3.10/site-packages (from black->symforce) (2.0.1)
Collecting pathspec>=0.9.0
  Downloading pathspec-0.10.2-py3-none-any.whl (28 kB)
Collecting click>=8.0.0
  Downloading click-8.1.3-py3-none-any.whl (96 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 96.6/96.6 kB 4.6 MB/s eta 0:00:00
Requirement already satisfied: platformdirs>=2 in /home/codespace/.local/lib/
python3.10/site-packages (from black->symforce) (2.5.4)
Requirement already satisfied: MarkupSafe>=2.0 in /home/codespace/.local/lib/
python3.10/site-packages (from jinja2->symforce) (2.1.1)
Installing collected packages: ply, mypy-extensions, mpmath, clang-format, argh,
sympy, symforce-sym, pathspec, graphviz, click, skymarshal, black, symforce
Successfully installed argh-0.26.2 black-22.10.0 clang-format-15.0.4 click-8.1.3
graphviz-0.20.1 mpmath-1.2.1 mypy-extensions-0.4.3 pathspec-0.10.2 ply-3.11
skymarshal-0.7.0 symforce-0.7.0 symforce-sym-0.7.0 sympy-1.11.1
```

1. Inisialisasi Library

In [2]:
```
import symforce

symforce.set_epsilon_to_symbol()

import numpy as np
from symforce import typing as T
from symforce.values import Values
```

1. Menambahkan fungsi initial values

In […
```
def build_initial_values() -> T.Tuple[Values, int, int]:
    """
    Creates a Values with numerical values for the constants in the problem,
    for the optimized variables
    """
    num_poses = 3
    num_landmarks = 3

    initial_values = Values(
        poses=[sf.Pose2.identity()] * num_poses,
        landmarks=[sf.V2(-2, 2), sf.V2(1, -3), sf.V2(5, 2)],
        distances=[1.7, 1.4],
        angles=np.deg2rad([[55, 245, -35], [95, 220, -20], [125, 220, -20]])
        epsilon=sf.numeric_epsilon,
    )

    return initial_values, num_poses, num_landmarks
```

1. Menambahkan fungsi residual

In [4…
```
import symforce.symbolic as sf


def bearing_residual(
    pose: sf.Pose2, landmark: sf.V2, angle: sf.Scalar, epsilon: sf.Scalar
) -> sf.V1:
    """
    Residual from a relative bearing measurement of a 2D pose to a landmark
    """
    t_body = pose.inverse() * landmark
    predicted_angle = sf.atan2(t_body[1], t_body[0], epsilon=epsilon)
    return sf.V1(sf.wrap_angle(predicted_angle - angle))


def odometry_residual(
    pose_a: sf.Pose2, pose_b: sf.Pose2, dist: sf.Scalar, epsilon: sf.Scalar
) -> sf.V1:
    """
    Residual from the scalar distance between two poses.
    """
    return sf.V1((pose_b.t - pose_a.t).norm(epsilon=epsilon) - dist)
```

1. Menambahkan fungsi factor dari library symforce

```
In [… from symforce.opt.factor import Factor


      def build_factors(num_poses: int, num_landmarks: int) -> T.Iterator[Factor]:

          for i in range(num_poses - 1):
              yield Factor(
                  residual=odometry_residual,
                  keys=[f"poses[{i}]", f"poses[{i + 1}]", f"distances[{i}]", "epsi
              )

          for i in range(num_poses):
              for j in range(num_landmarks):
                  yield Factor(
                      residual=bearing_residual,
                      keys=[f"poses[{i}]", f"landmarks[{j}]", f"angles[{i}][{j}]",
                  )
```

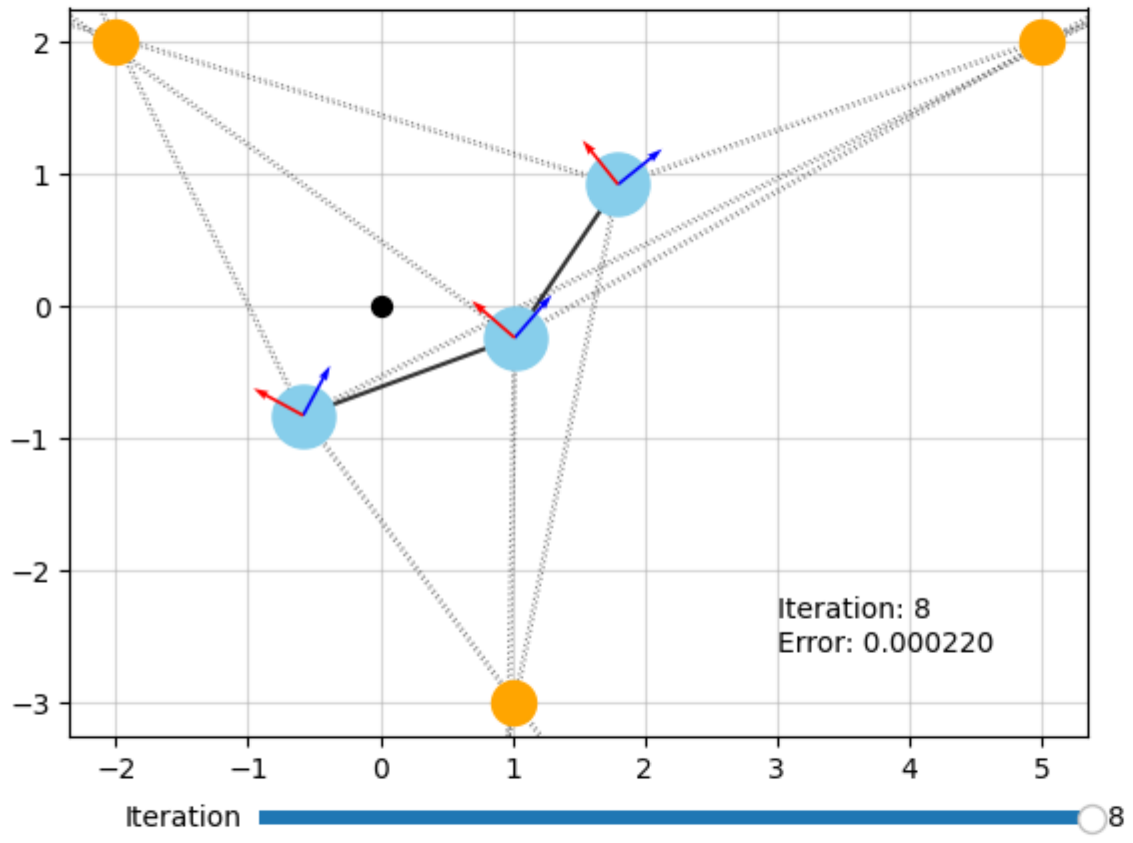
1. Membuat fungsi main untuk menampilkan hasil

In […
```python
from symforce.opt.optimizer import Optimizer


def main() -> None:
    # Create a problem setup and initial guess
    initial_values, num_poses, num_landmarks = build_initial_values()

    # Create factors
    factors = build_factors(num_poses=num_poses, num_landmarks=num_landmarks

    # Select the keys to optimize - the rest will be held constant
    optimized_keys = [f"poses[{i}]" for i in range(num_poses)]

    # Create the optimizer
    optimizer = Optimizer(
        factors=factors,
        optimized_keys=optimized_keys,
        debug_stats=True,  # Return problem stats for every iteration
        params=Optimizer.Params(verbose=True),  # Customize optimizer behavi
    )

    # Solve and return the result
    result = optimizer.optimize(initial_values)

    # Print some values
    print(f"Num iterations: {len(result.iteration_stats) - 1}")
    print(f"Final error: {result.error():.6f}")

    for i, pose in enumerate(result.optimized_values["poses"]):
        print(f"Pose {i}: t = {pose.position()}, heading = {pose.rotation().

    # Plot the result
    # TODO(hayk): mypy gives the below error, but a relative import also doe
    # Skipping analyzing "symforce.examples.robot_2d_localization.plotting":
    #     found module but no type hints or library stubs
    from symforce.examples.robot_2d_localization.plotting import plot_soluti

    plot_solution(optimizer, result)
```

1. Memanggil fungsi main untuk menampilkan output result

In [7]:
```python
if __name__ == "__main__":
    main()
```

```
[2022-12-04 14:41:27.399] [info] LM<sym::Optimize> [iter    0] lambda:
1.000e+00, error prev/linear/new: 6.396/2.952/2.282, rel reduction: 0.64328
[2022-12-04 14:41:27.400] [info] LM<sym::Optimize> [iter    1] lambda:
2.500e-01, error prev/linear/new: 2.282/0.088/0.074, rel reduction: 0.96768
Num iterations: 8
Final error: 0.000220
Pose 0: t = [[-0.58303818]
 [-0.82449079]], heading = [1.073486]
Pose 1: t = [[ 1.01671023]
 [-0.23835618]], heading = [0.85760621]
Pose 2: t = [[1.79784992]
 [0.92055145]], heading = [0.67637098]
[2022-12-04 14:41:27.402] [info] LM<sym::Optimize> [iter    2] lambda:
6.250e-02, error prev/linear/new: 0.074/0.007/0.007, rel reduction: 0.91152
[2022-12-04 14:41:27.402] [info] LM<sym::Optimize> [iter    3] lambda:
1.562e-02, error prev/linear/new: 0.007/0.001/0.001, rel reduction: 0.90289
[2022-12-04 14:41:27.403] [info] LM<sym::Optimize> [iter    4] lambda:
3.906e-03, error prev/linear/new: 0.001/0.000/0.000, rel reduction: 0.61885
[2022-12-04 14:41:27.403] [info] LM<sym::Optimize> [iter    5] lambda:
9.766e-04, error prev/linear/new: 0.000/0.000/0.000, rel reduction: 0.08876
[2022-12-04 14:41:27.404] [info] LM<sym::Optimize> [iter    6] lambda:
2.441e-04, error prev/linear/new: 0.000/0.000/0.000, rel reduction: 0.00013
[2022-12-04 14:41:27.405] [info] LM<sym::Optimize> [iter    7] lambda:
6.104e-05, error prev/linear/new: 0.000/0.000/0.000, rel reduction: 0.00000
```


Iteration: 8
Error: 0.000220
Iteration