Long-Term Accuracy in Sea Navigation

without using GNSS (Global Navigation Satellite Systems)

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Self introduction

- Mårten Lager
- Industrial Ph.D. student at Computer Science at LTH
- Part of the research program ”WASP” (Wallenberg Autonomous Systems and Software Program)
- Employed at Saab Kockums

Navigation at Sea Today

- High performance
- Much about GPS
- Digital Sea Charts
- Inertial Navigation Systems (orientation, acceleration)
- Echo Sounder System (bottom depth)

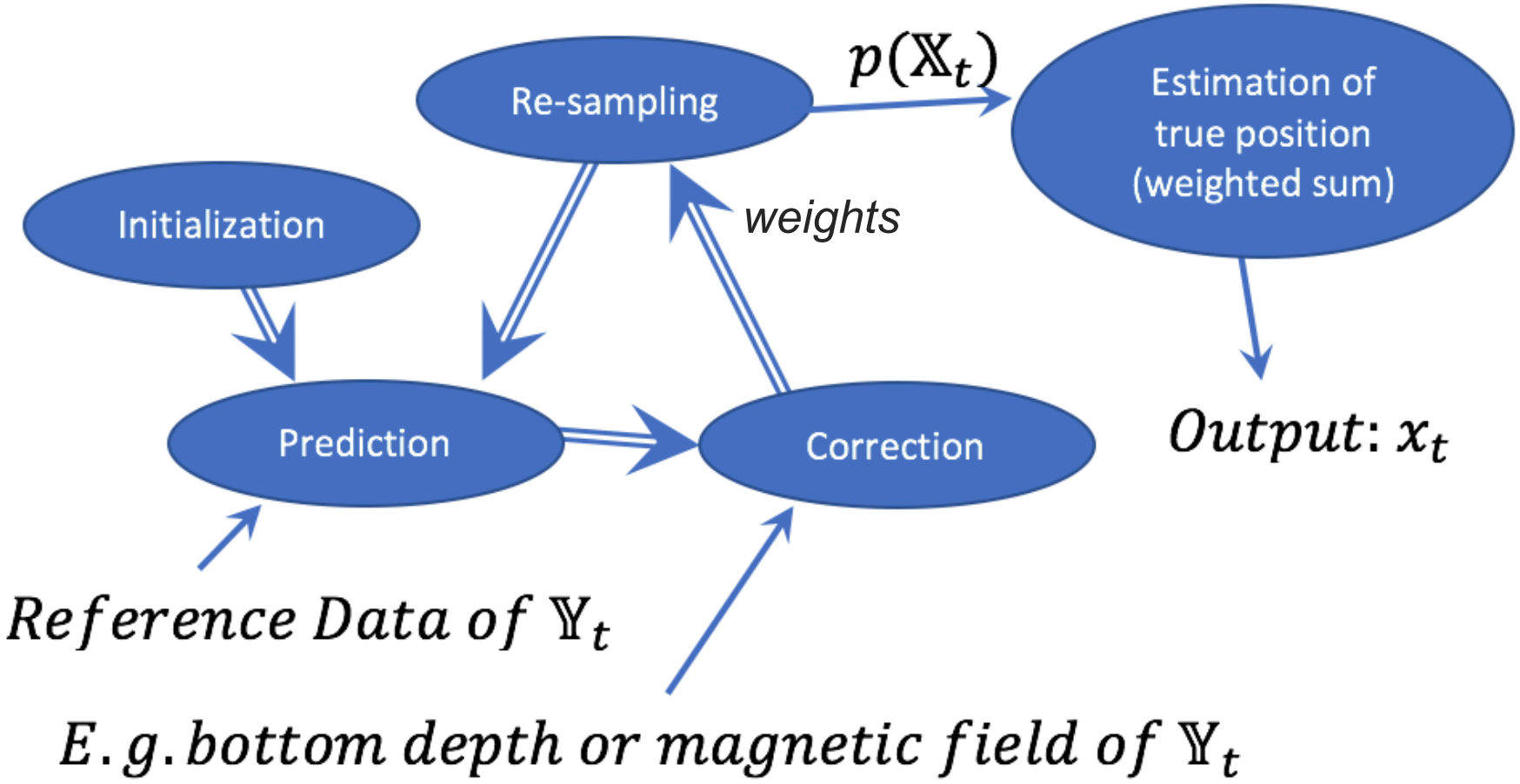
Disadvantage with GPS

- Dependent on external systems
- Can be jammed
- Can be spoofed
- In some situations, GPS does not work, e.g. for submarines

The idea

- Measure other things that vary with the position
- Use Particle Filter to estimate the position

Particle Filter algorithm

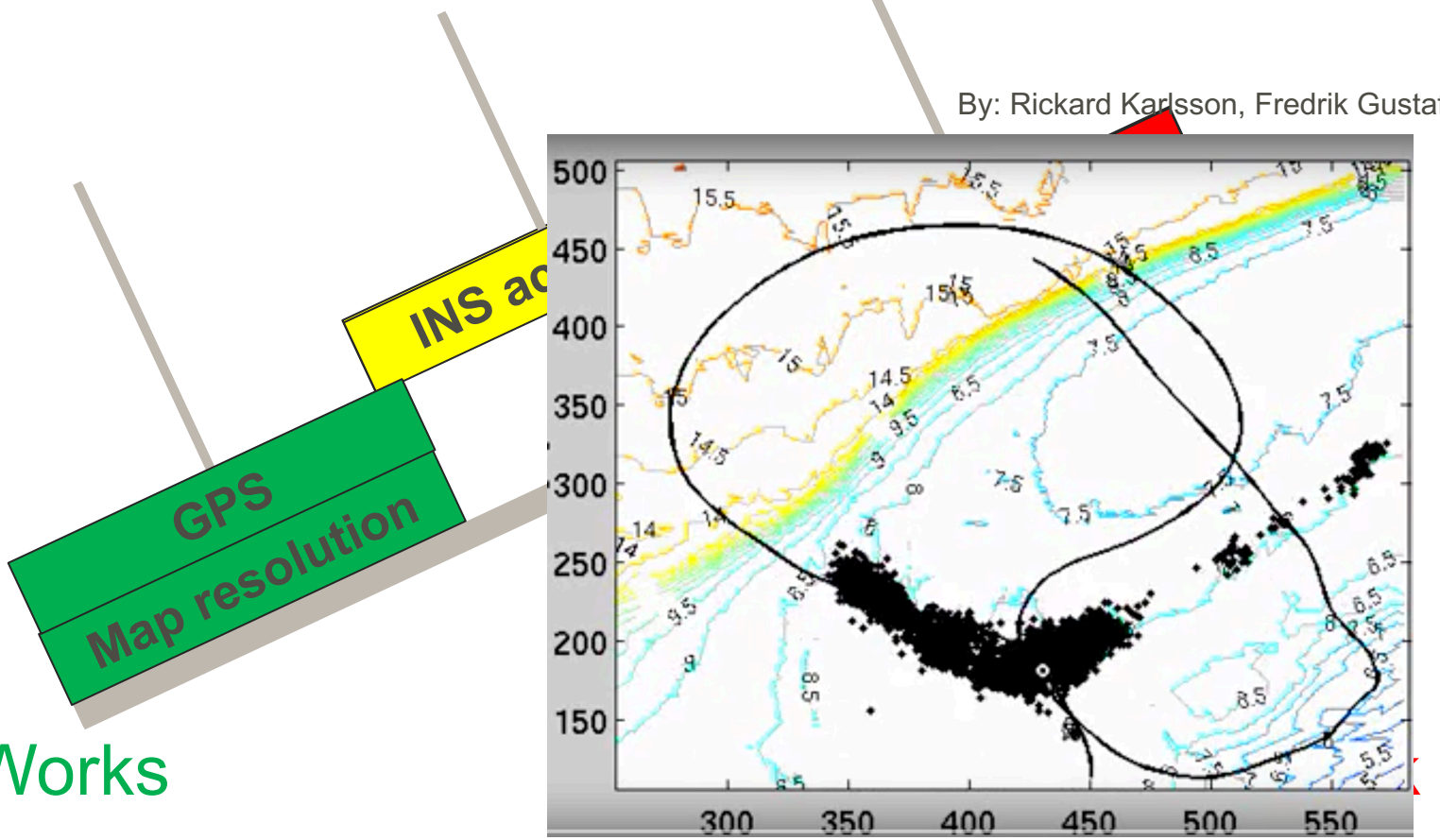


Limitations with current research

Normal Sample Filter

Using Particle Filter

By: Rickard Karlsson, Fredrik Gustafsson



Works

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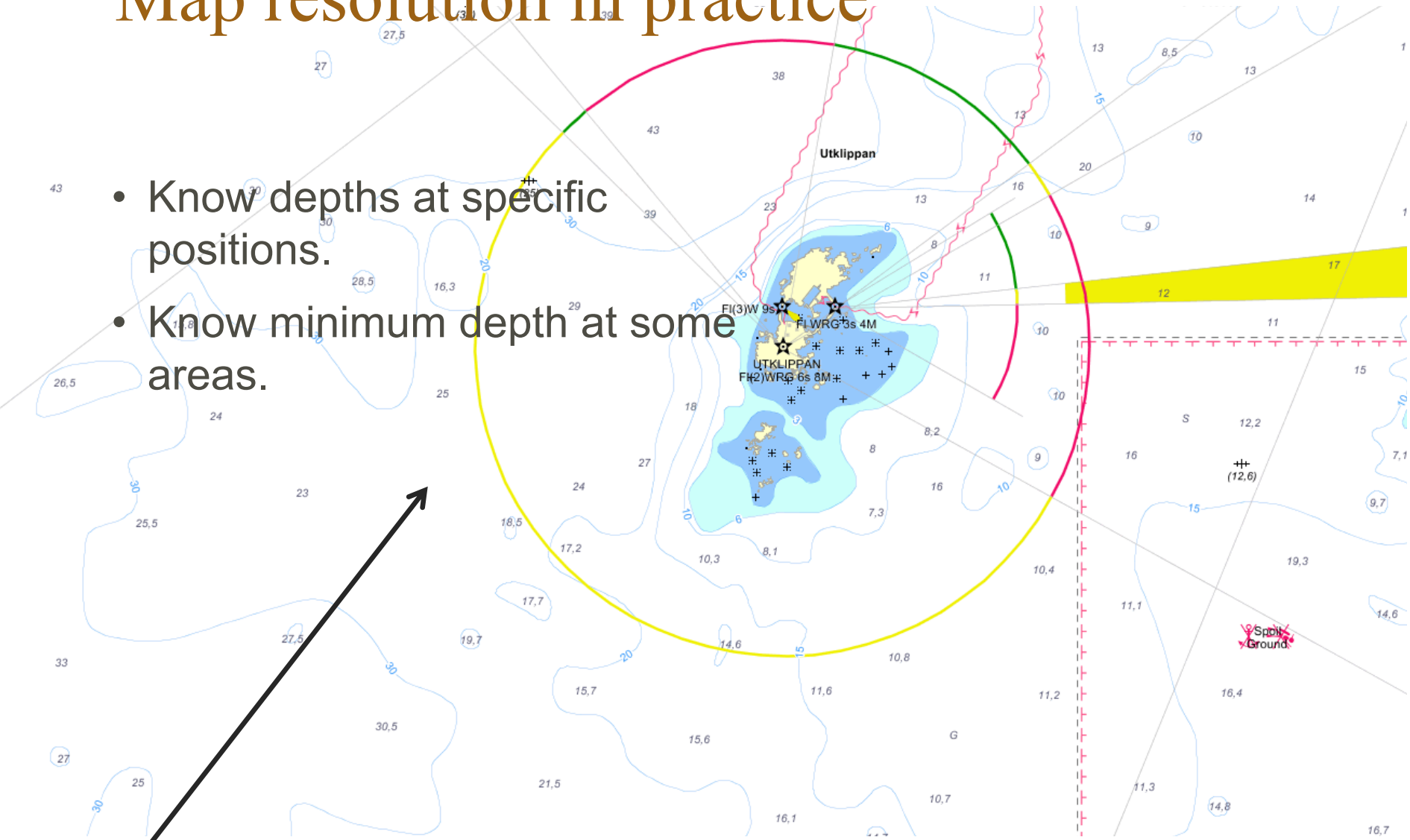
Map resolution in practice

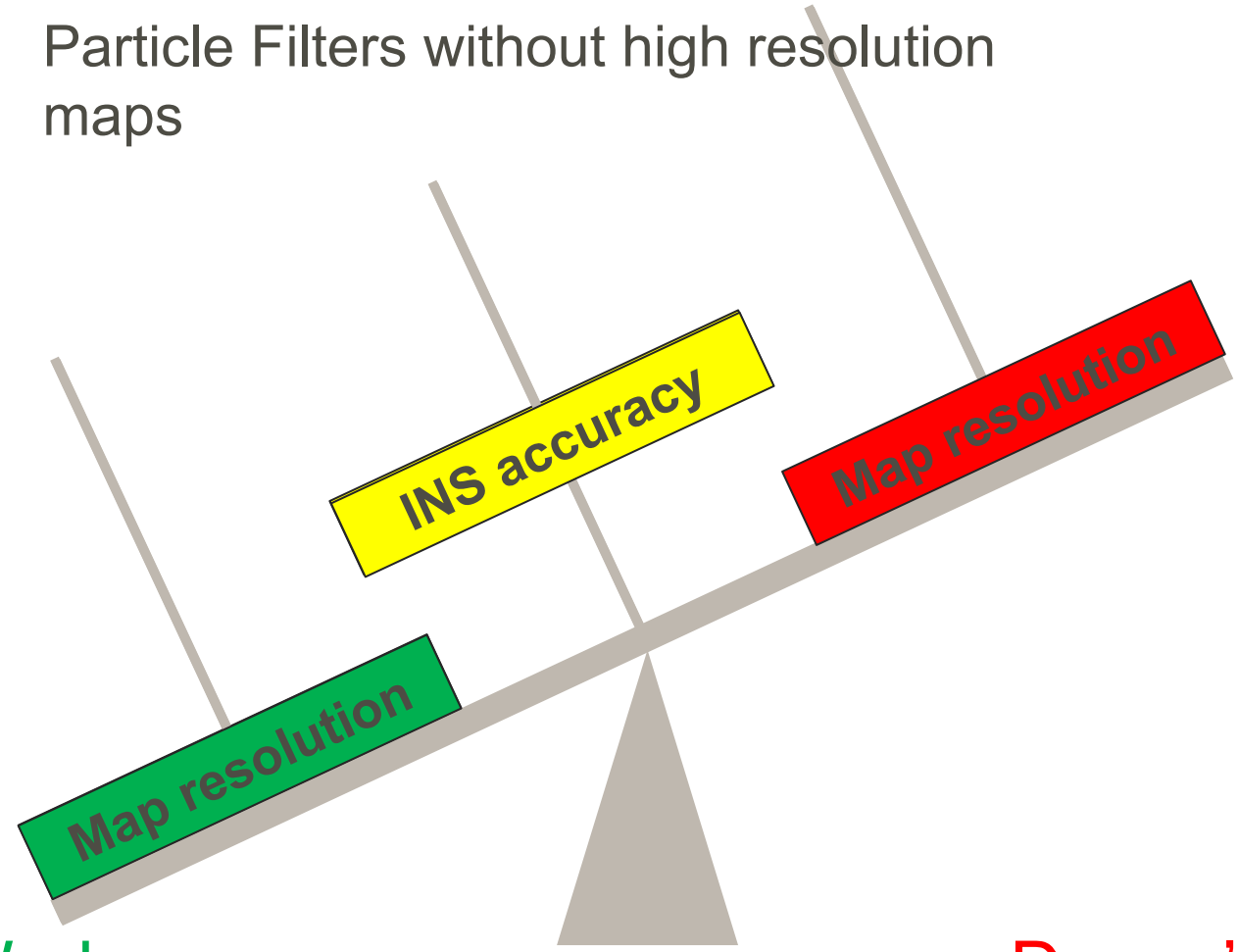
- Know depths at specific positions.
- Know minimum depth at some areas.



- At least 20 m. Depths of 25 m, 23 m and 18,5 m near by.

Limitations with current research

Particle Filters without high resolution maps



Works

Doesn't Work

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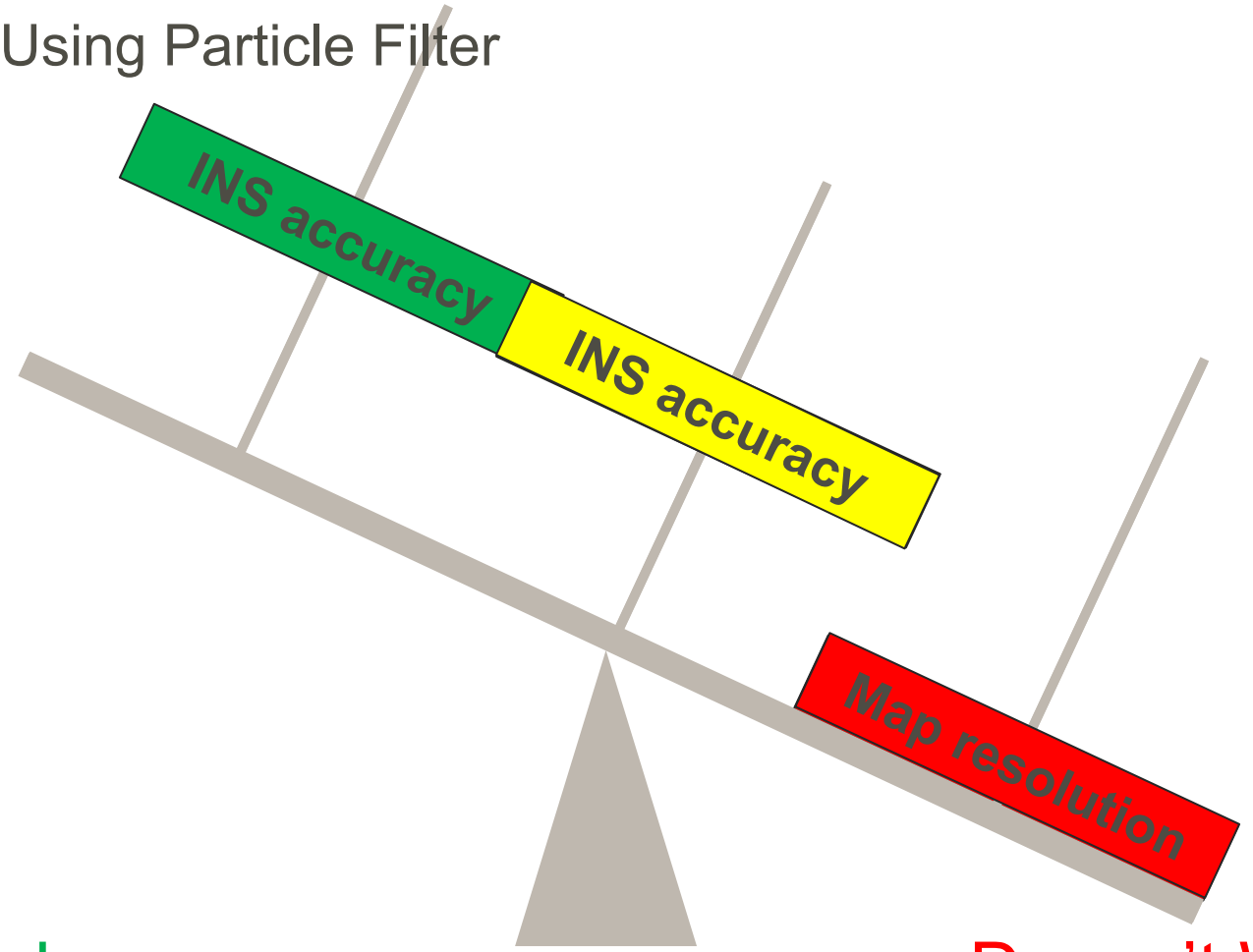
Limitations with current research

Using Particle Filter



Works

Doesn't Work

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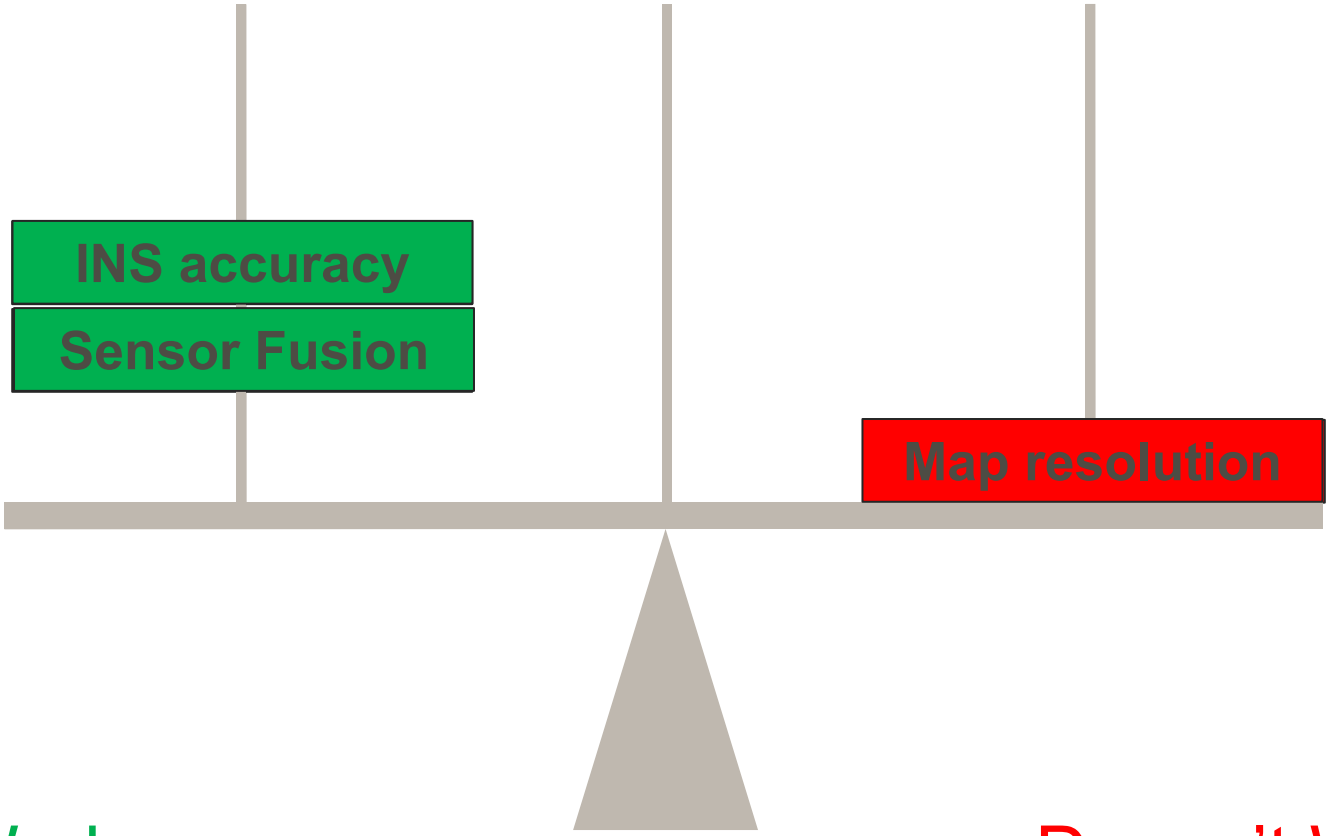
Limitations with current research

Using Particle Filter



Works

Doesn't Work

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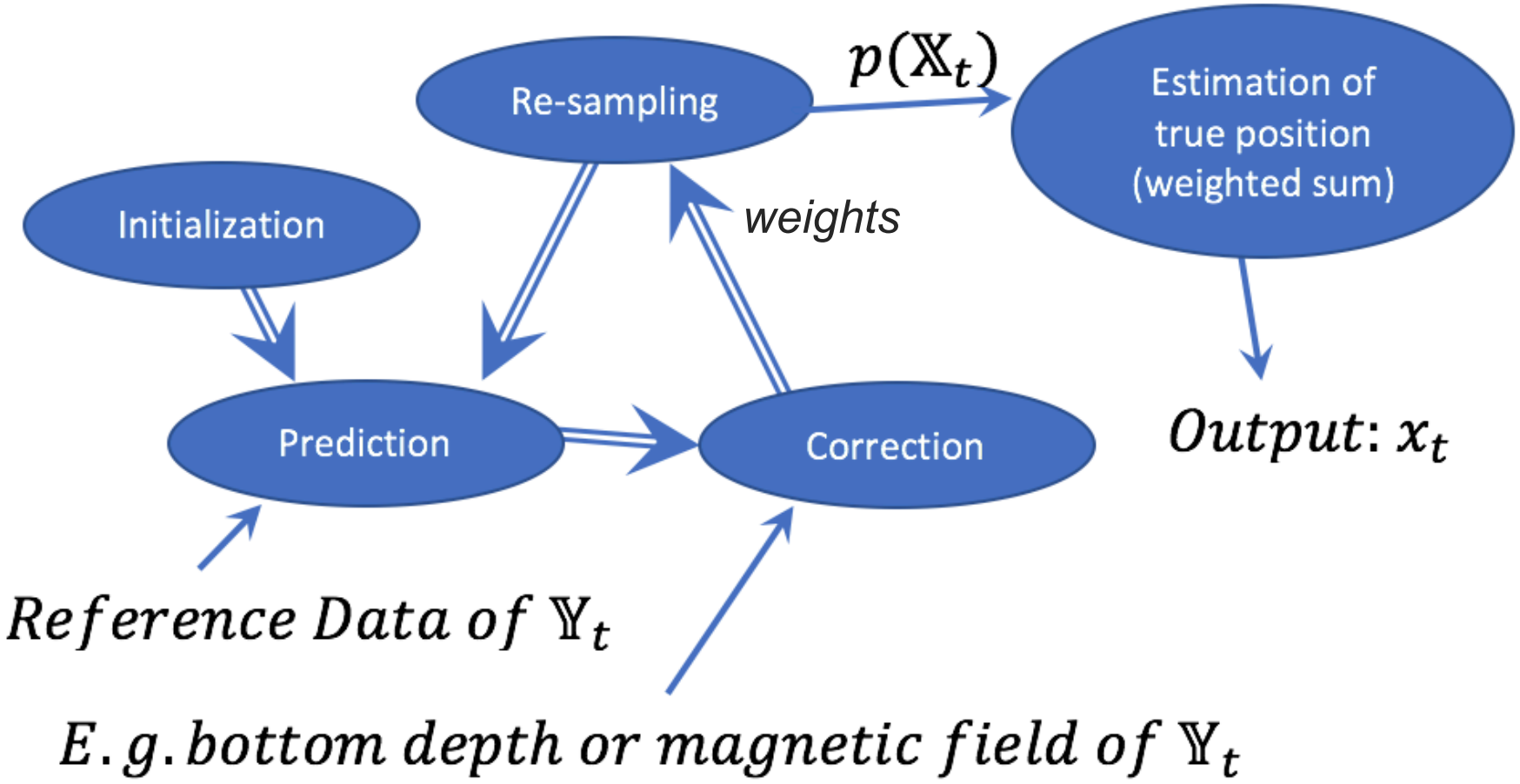
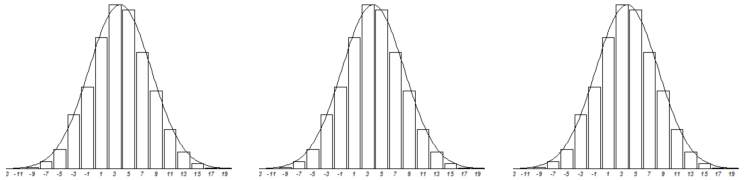
Research question

Is it possible to navigate accurately enough without GNSS systems, only relying on high performance navigation sensors and normal sea chart and magnetic charts?

Particle Filter algorithm

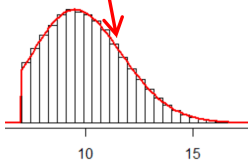


Creating a Probability Density Function

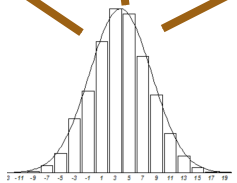


Magnetic value – 3 axis

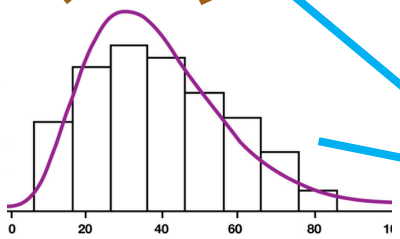
Probability of measuring a depth of 11-12 m.



Bottom depth



Magnetic value



Combined PDF

Subset	Likelihood of evaluating with subset
Only magnetic field	10 %
Only bottom depth	20 %
Depth and magnetic field (combined)	50 %
No Particle Filter (Only Reference Data)	20 %

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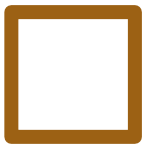
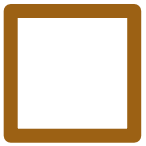
Program development

- Simple PF simulation for depth analysis



- More accurate simulation with support for depth and magnetic analysis. Evaluation of performance.



- Test of program at sea

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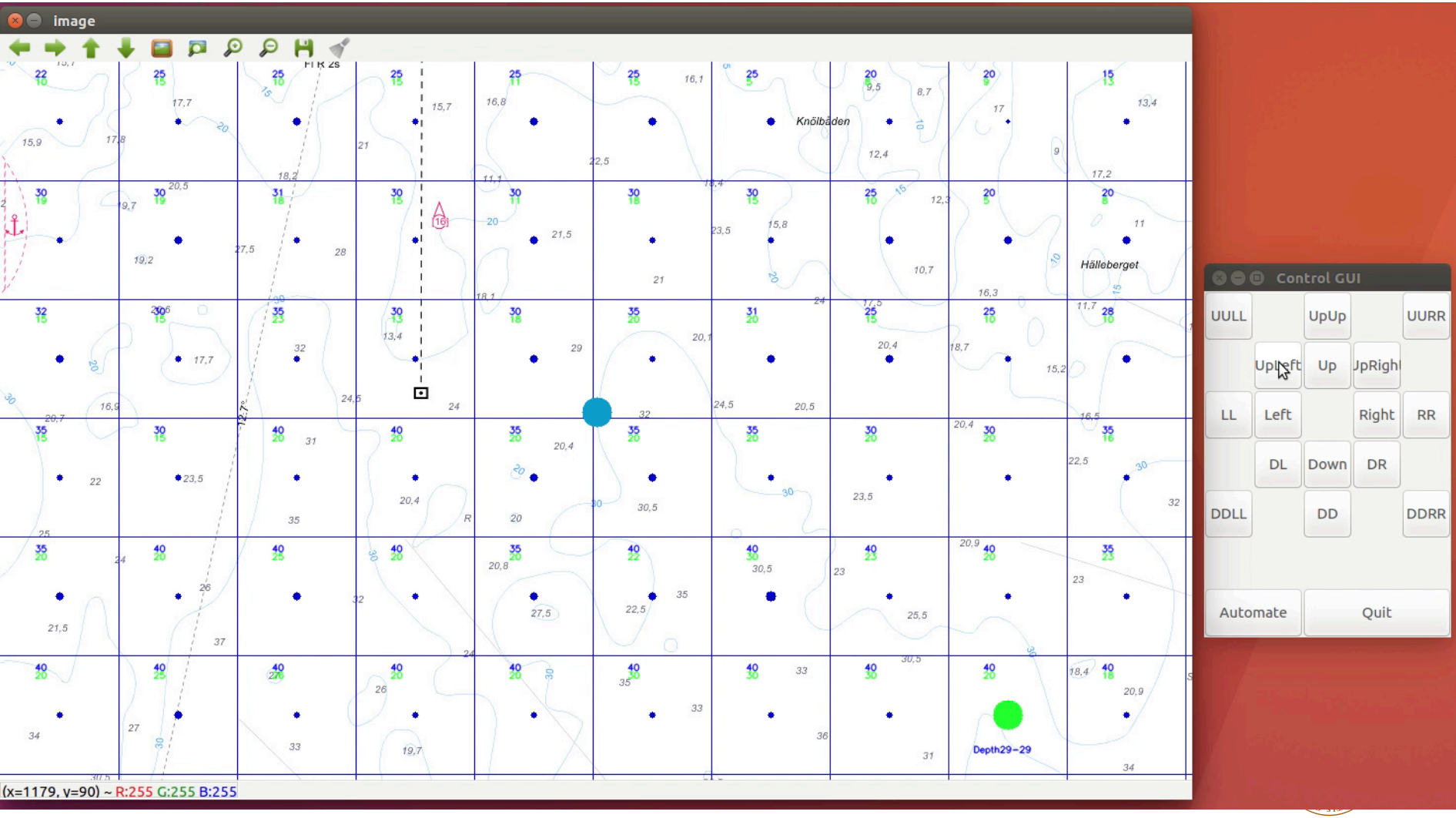
Demonstration



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Conclusion

- Finished with the initial program
- Ready to take the next step with algorithm 2.0, where I will evaluate the performance and see how well it works

Thank you for listening!

Questions?