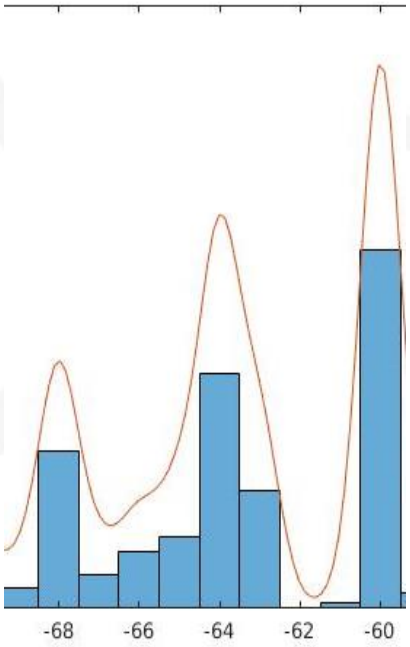
Helvar



Indoor Positioning Demo

Srikanth Gadicherla
Master Thesis Work

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ACKNOWLEDGEMENTS

I would like to thank Henri, Max, Heikki, Abi and Jukka for all their help and support.

INTRODUCTION

WHAT IS INDOOR POSITIONING (IP)?

- Positioning oneself in the indoor environment using the measurements from the sensors.
- Here, the measurements are **received signal strength indicator** (RSSI).
- Measurements could be from magnetometer (magnetic field), inertial measurement unit (IMU; velocity, acceleration, heading).
- Used technologies for Assisted GPS, LED's, WiFi, Visual light communication, Bluetooth Low Energy (BLE; Bluetooth Smart) etc.
- Now solutions use *signals of opportunity* like magnetic field, pressure, light, sound intensity, GSM mobile signals, GNSS etc.

WHY DO WE NEED INDOOR POSITIONING?

INTRODUCTION

WHY DO WE NEED INDOOR POSITIONING?

- The Ubiquitous GPS fails indoors due to signal attenuation.
- The uncertainty of the estimation generally spans over several meters which usually covers many rooms, or in worst case even a floor.
- According to Geospatial World (August 2014), the market for Indoor Positioning would be over **4 billion** US dollars by 2018 and ABI research claims **10 billion** US dollars by 2020.
- It is challenging problem to solve.
  - Multipath and fading.
  - User/ Indoor setting movement causes fluctuation called fading. Even in movement of door can add some bias.
  - Signal interference 2.4 GHz license-free frequency.
  - Signal attenuation also dependent on the number of people indoors.
  - The access points would be unheard, the data is sparse.

INTRODUCTION

POSSIBLE USE CASES

- Person trying to find a particular location in the indoor space (B2C and B2B).
  - Room in a hospital
  - Shop in a mall
  - Terminal in an airport
  - Product in a shop
- Product flow optimization with asset tracking (B2B).
  - For example in a hospital or in a warehouse, with the location data we can propose its flow to maximize its usage.
- Personalized product recommendations (B2B).
  - We could use the location data of what all products the customers have visited and send them targeted advertisements.

HOW IS HELVAR SOLVING THE IP PROBLEM?

SOLUTION

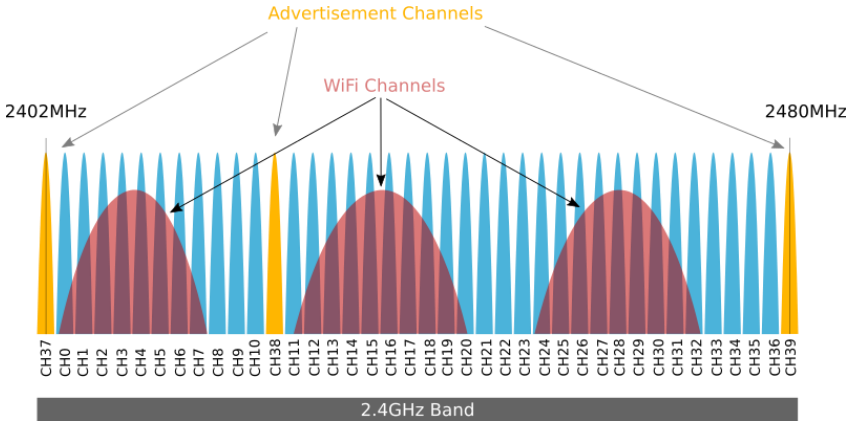
HOW IS HELVAR SOLVING THE IP PROBLEM?

We are solving it by "BLE Location Fingerprinting using Gaussian Process measurement model based Particle Filter"

LETS TAKE IT FROM THE BOTTOM

SOLUTION

BLUETOOTH LOW ENERGY (BLE)



Radio channels in the BLE. Specifically showing the advertisement channels.

Courtesy: http://www.argenox.com/a-ble-advertising-primer/

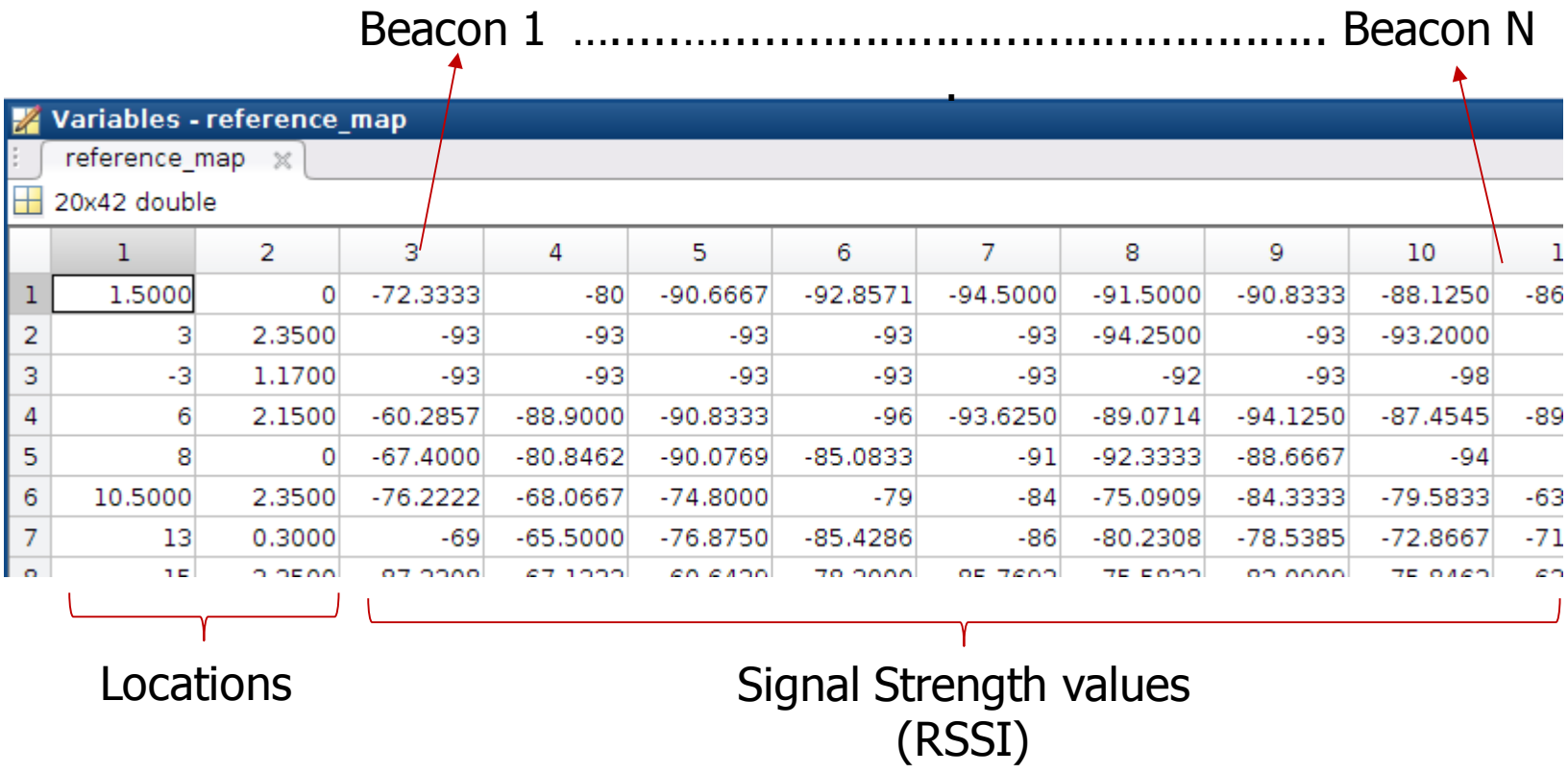
- Bluetooth Low Energy or Bluetooth Smart is not similar to conventional Bluetooth technology runs on 2.4GHz license free channel.
- It runs on coin cell battery (typically 100 - 500 mAh). This usually lasts from few months to several years.
- For indoor positioning, the mobile devices reads the advertisements and gives out the signal strength values with the corresponding MAC address.
- We have the beacons embedded in the CSR mesh which makes the ActiveAhead.

SOLUTION

LOCATION FINGERPRINTING

SOLUTION

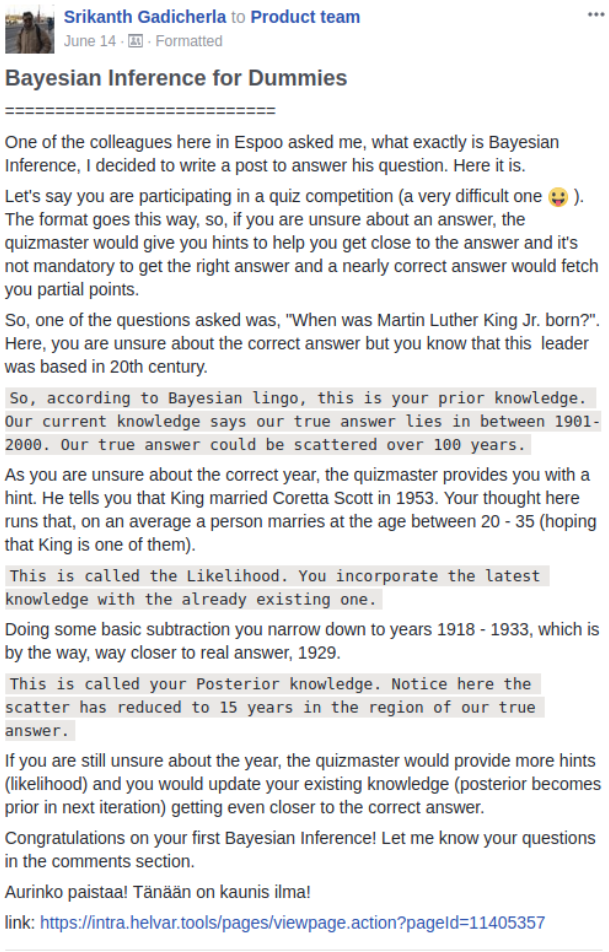
LOCATION FINGERPRINTING



	1	2	3	4	5	6	7	8	9	10	1
1	1.5000	0	-72.3333	-80	-90.6667	-92.8571	-94.5000	-91.5000	-90.8333	-88.1250	-86
2	3	2.3500	-93	-93	-93	-93	-93	-94.2500	-93	-93.2000	
3	-3	1.1700	-93	-93	-93	-93	-93	-92	-93	-98	
4	6	2.1500	-60.2857	-88.9000	-90.8333	-96	-93.6250	-89.0714	-94.1250	-87.4545	-89
5	8	0	-67.4000	-80.8462	-90.0769	-85.0833	-91	-92.3333	-88.6667	-94	
6	10.5000	2.3500	-76.2222	-68.0667	-74.8000	-79	-84	-75.0909	-84.3333	-79.5833	-63
7	13	0.3000	-69	-65.5000	-76.8750	-85.4286	-86	-80.2308	-78.5385	-72.8667	-71

SOLUTION

GAUSSIAN PROCESSES



Srikanth Gadicherla to Product team
June 14 · Formatted

Bayesian Inference for Dummies

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One of the colleagues here in Espoo asked me, what exactly is Bayesian Inference, I decided to write a post to answer his question. Here it is.

Let's say you are participating in a quiz competition (a very difficult one 😀). The format goes this way, so, if you are unsure about an answer, the quizmaster would give you hints to help you get close to the answer and it's not mandatory to get the right answer and a nearly correct answer would fetch you partial points.

So, one of the questions asked was, "When was Martin Luther King Jr. born?". Here, you are unsure about the correct answer but you know that this leader was based in 20th century.

`So, according to Bayesian lingo, this is your prior knowledge. Our current knowledge says our true answer lies in between 1901-2000. Our true answer could be scattered over 100 years.`

As you are unsure about the correct year, the quizmaster provides you with a hint. He tells you that King married Coretta Scott in 1953. Your thought here runs that, on an average a person marries at the age between 20 - 35 (hoping that King is one of them).

`This is called the Likelihood. You incorporate the latest knowledge with the already existing one.`

Doing some basic subtraction you narrow down to years 1918 - 1933, which is by the way, way closer to real answer, 1929.

`This is called your Posterior knowledge. Notice here the scatter has reduced to 15 years in the region of our true answer.`

If you are still unsure about the year, the quizmaster would provide more hints (likelihood) and you would update your existing knowledge (posterior becomes prior in next iteration) getting even closer to the correct answer.

Congratulations on your first Bayesian Inference! Let me know your questions in the comments section.

Aurinko paistaa! Tänään on kaunis ilma!

link: https://intra.helvar.tools/pages/viewpage.action?pageId=11405357

- Gaussian processes (GPs) are generalization of the ubiquitous Gaussian distribution.
- GPs are non-parametric kernel methods and they allow us to perform Bayesian inference over functions.
- They are mainly dependent of kernel matrix which encodes spatial relation of data points.

SOLUTION

GAUSSIAN PROCESSES PRIOR DISTRIBUTIONS

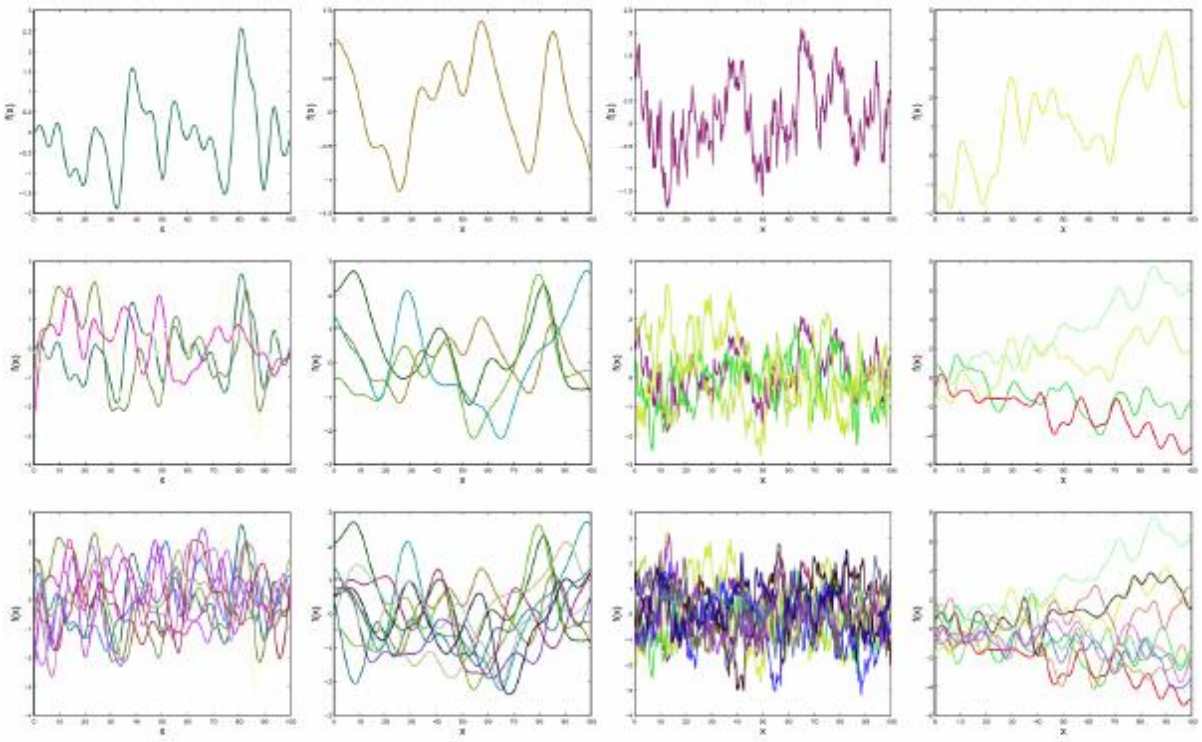
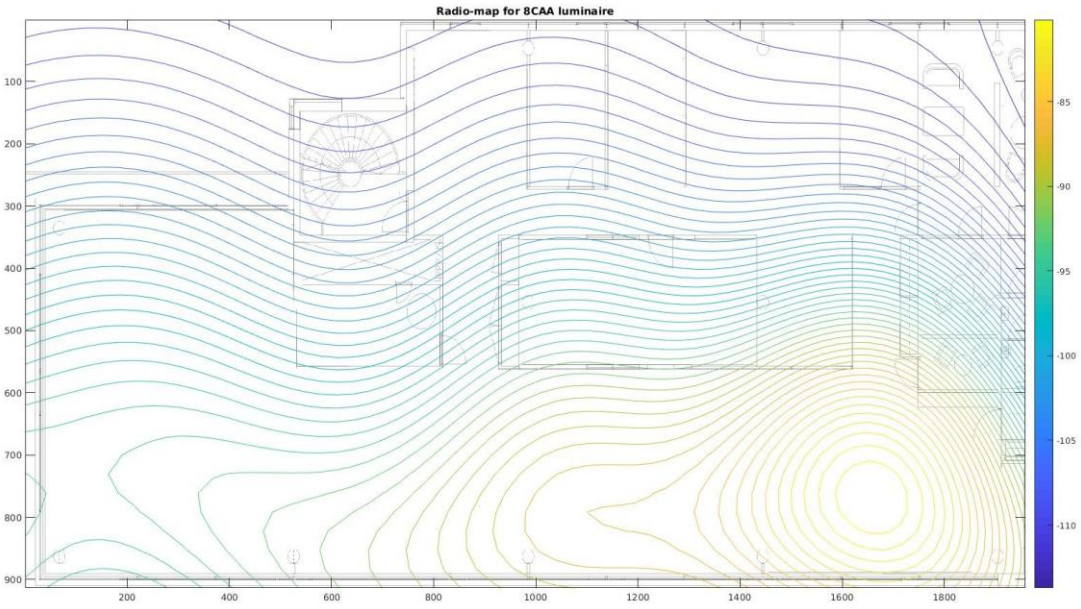
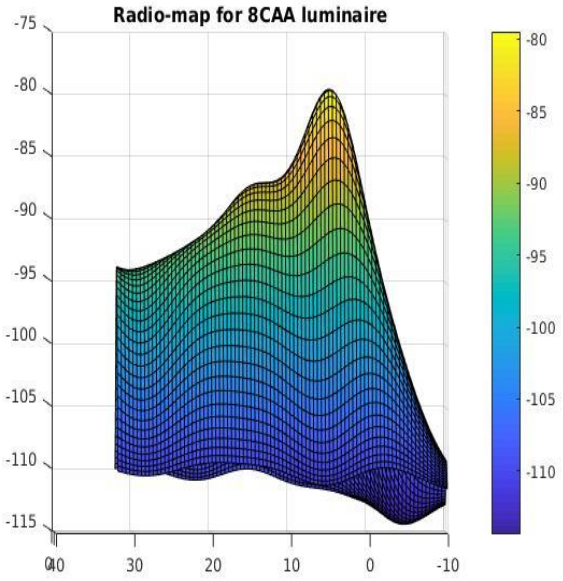


Figure: courtesy: Zoubin Ghahramani
/http://mlg.eng.cam.ac.uk/zoubin/talks/uai05tutorial-b.pdf

SOLUTION

GAUSSIAN PROCESSES





SOLUTION

PARTICLE FILTERS

- Particle filter is a sequential Monte Carlo state-space inference method.
- In our solution, we have used simple quasi constant (x_t = x_t-1 + dt) as *dynamic model* and GP as *measurement model*.
- Algorithm below (courtesy Simo Särkkä, 2013)

Bootstrap Filter

- Draw point $\mathbf{x}_k^{(i)}$ from the dynamic model:

$$\mathbf{x}_k^{(i)} \sim p(\mathbf{x}_k \mid \mathbf{x}_{k-1}^{(i)}), \qquad i = 1, \ldots, N.$$

- Calculate new weights

$$w_k^{(i)} \propto p(\mathbf{y}_k \mid \mathbf{x}_k^{(i)}), \qquad i = 1, \ldots, N,$$

  and normalize them to sum to unity.

- Perform resampling.

DEMO

MACHINE LEARNING IS LIKE MEDICINE,
WE DON'T GIVE GUARANTEES.

WE GIVE UNCERTAINTIES.

Helvar

FREEDOM IN LIGHTING
WITH FUTURE TECHNOLOGIES

QUESTIONS !!

THANK YOU