MicroBayes

https://persyval-lab.org/en/sites/content/microbayes

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TIMA — Laurent Fesquet

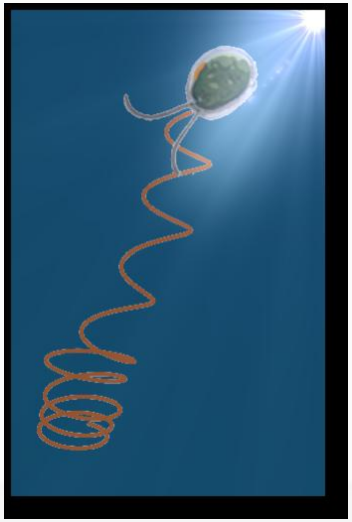
gipsa-lab — Laurent Girin

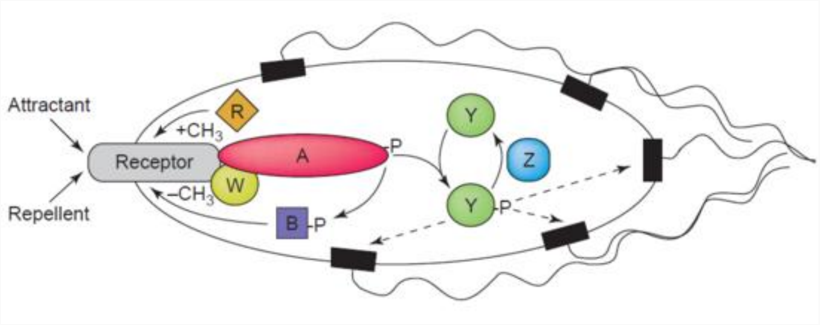
Agenda

- Context
- Project Description
- First results
- Future work

Motivation

- Need for low power computing
- The actual technology reaches some limits
- Need to better understand computation



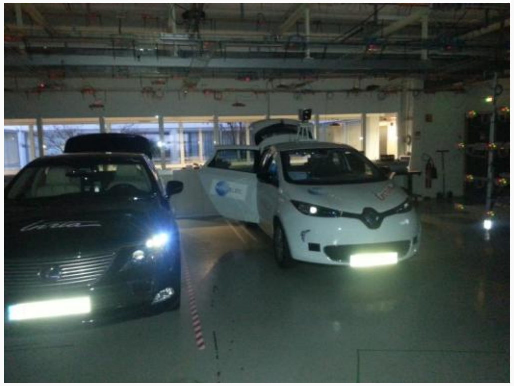


Energy consumption

~ 200 kW
~ 3,9m³

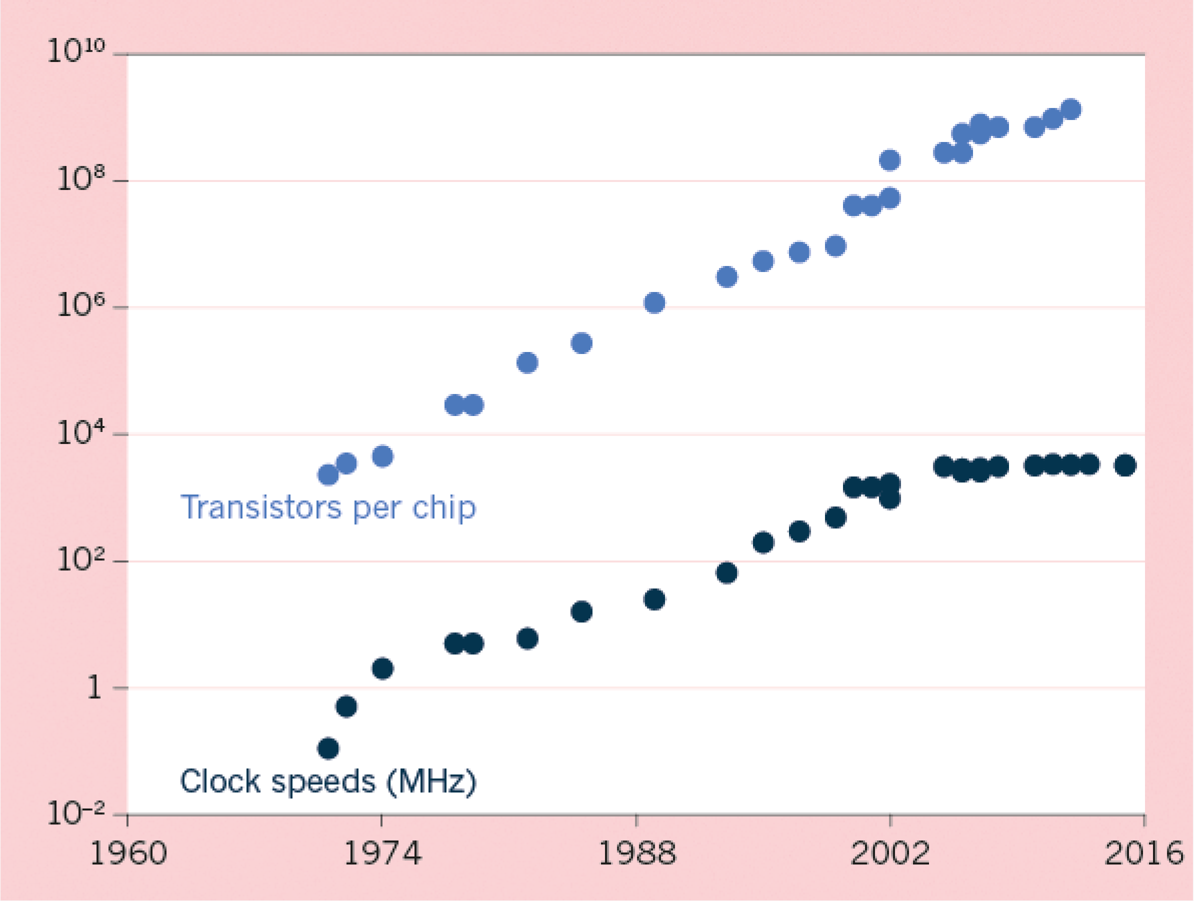
~ 20 W
~ 1,3 L

1 Stereo Camera
+
2 lidars



~ 1 kW
~ 0.5 m³

Moore's Law limits



The rebooting computing endeavour

- Quantum computing
- Neuromorphic computing
  - IBM True North
  - HBP SpiNNaker
  - Machine dedicated to Deep Neural Nets, Conv Nets
    - Google Convnet
    - Facebook Big Basin
    - CEA-leti N2 D2
    - Nvidia….
  - Reservoir computing

Specialized hardware for Bayesian inference

- Vigoda (MIT) -> Lyrics – analog device
  - Analog computing
- Jonas – Masingka (MIT)
  - Probabilistic programming
  - Sampling machines with fixed point arithmetic's
- Blanche (University of Arizona)
  - Bayesian inference with optical hardware
- Takhur (Sydney University), Friedman (IEF)
  - Magnetic Tunnel Junction

Bambi

- Design of a first generation of stochastic machines dedicated to Bayesian Inference

BAMBI
Bottom-up Approaches to Machines dedicated to Bayesian Inference

SEVENTH FRAMEWORK PROGRAMME

MicroBayes

- Goal : Design and implementation of stochastic Machines for Low-level Sensor Interpretation with Bayesian inference.

- Started in November 2016
- 1 Phd: Raphael Frisch (Persyval)
- 1 Post-doc for 6 months (Bambi)
- 1 Post-doc for 2 years (Persyval)

Project team

Mathematical Proofs

INSTITUT FOURIER

Didier Piau

Applications

LIG

Emmanuel Mazer
Raphael Frisch

MICROBAYES

Laurent Girin

gipsa-lab

Programming

Laurent Fesquet

tima

Architecture Hardware

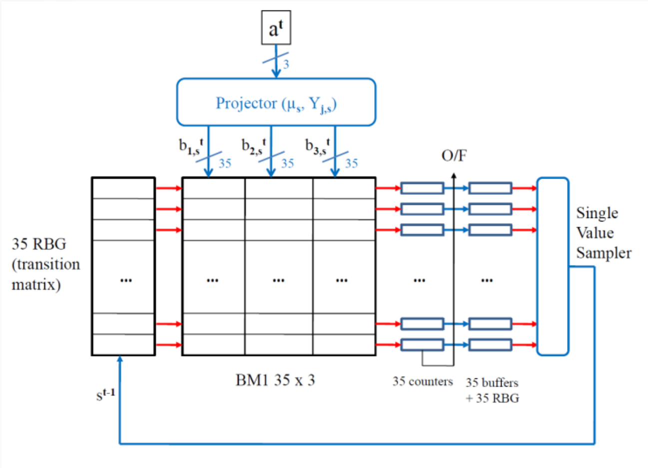
PhD thesis

- Use of dedicated machines for Bayesian inference
- Explore new approaches of sampling strategies
- Applications
  - Sound source localization
  - Sound source separation
- Started 11/2016
- Currently writing a paper for ICRC 2017
- Summer 2017 : attending a summer school on **Probabilistic Programming** in Washington DC

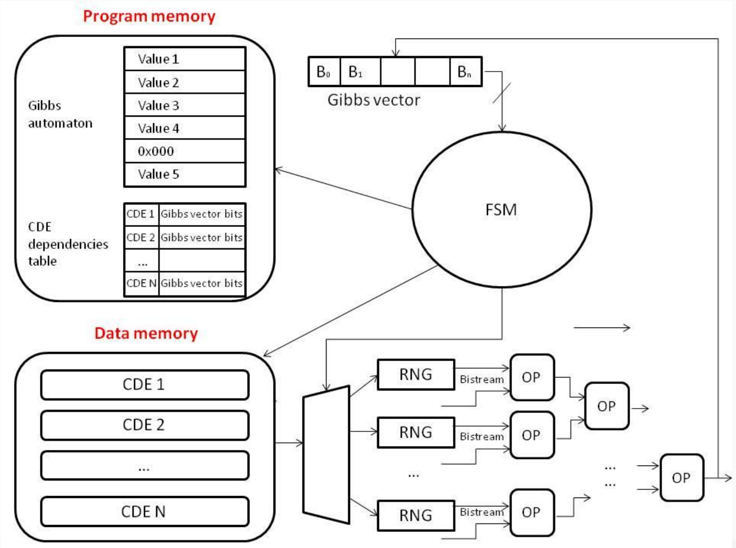
Bayesian machines

- BM1: Parallel sampling
  - Very fast machine
  - Search space < 2^{12}

2^{12}



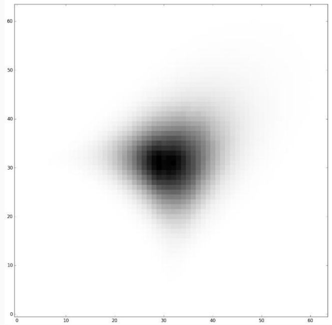
- BM2: Sequential sampling
  - Untractable problems > 2^{100}



Sampling Machines

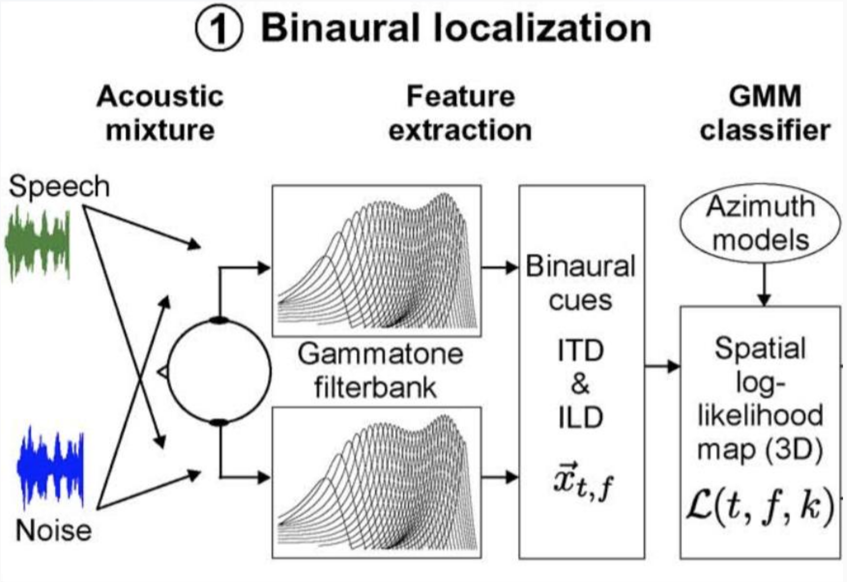
- Representing probability distributions
  - With parameters : Normal (μ, σ)
  - With N samples

$$P(x_i y_i) \approx \frac{\sum_{k=1}^{N} \partial_{x_k, y_k = x_i, y_j}}{N}$$



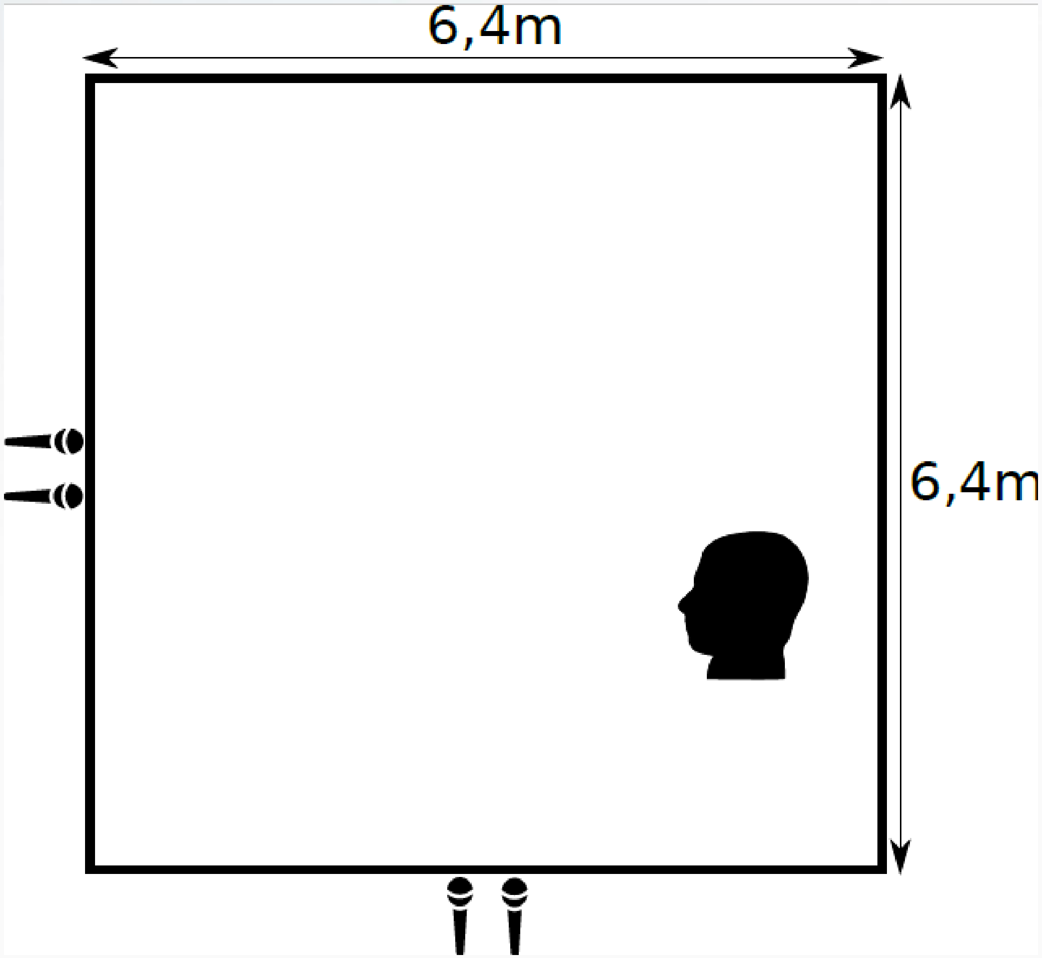
  - Stochastic bus : Parallel sampling
  - With constraints
    - Maximum entropy distribution :

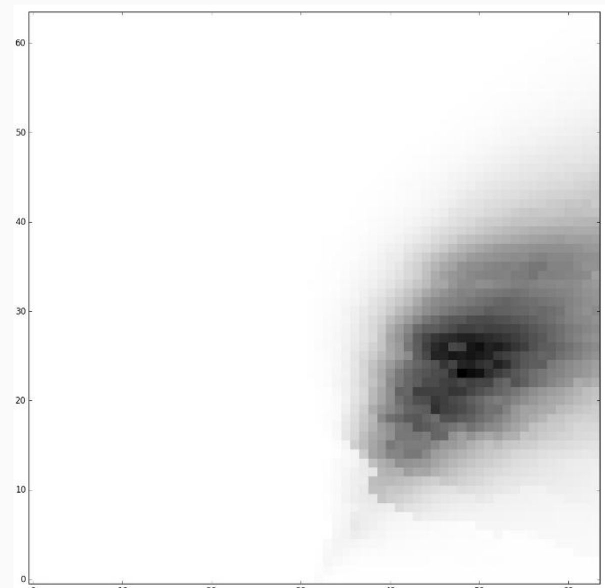
Sound source localization



- Use of parallel sampling
  - Bayesian Machine with FPU preprocessing

Principle with source localization



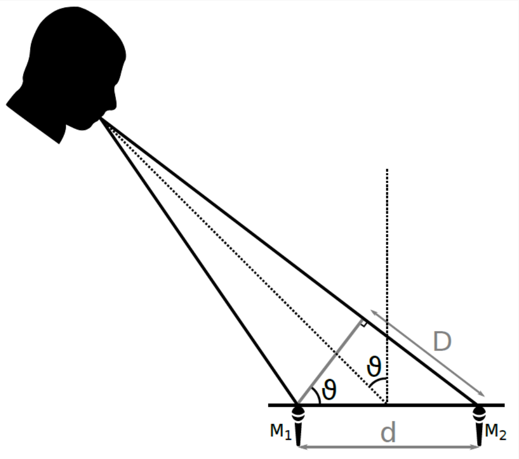


Sound source localization : evidences

- Sensors: pair of microphones
- Assuming the free field model
- Evidence : InterChannel Phase Difference (ICPD)

$$R(k) = \frac{Y_2(k,l)}{Y_1(k,l)} \simeq \frac{A_2(k) \cdot S(k,l)}{A_1(k) \cdot S(k,l)} = \frac{A_2(k)}{A_1(k)}$$

$$\begin{aligned} ICPD(k) &= arg(R(k)) \\ &= arg(A_2(k)) - arg(A_2(k)) \\ &= \Delta\Phi(k) \\ &= \Phi_2(k) - \Phi_1(k) \end{aligned}$$



Stochastic bit streams

- Probability encoding

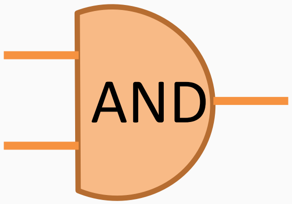
  Bit stream: 1010011001110100

  Probability: 0.5

- Probability multiplication

  1010011001110100

  0010100000101000



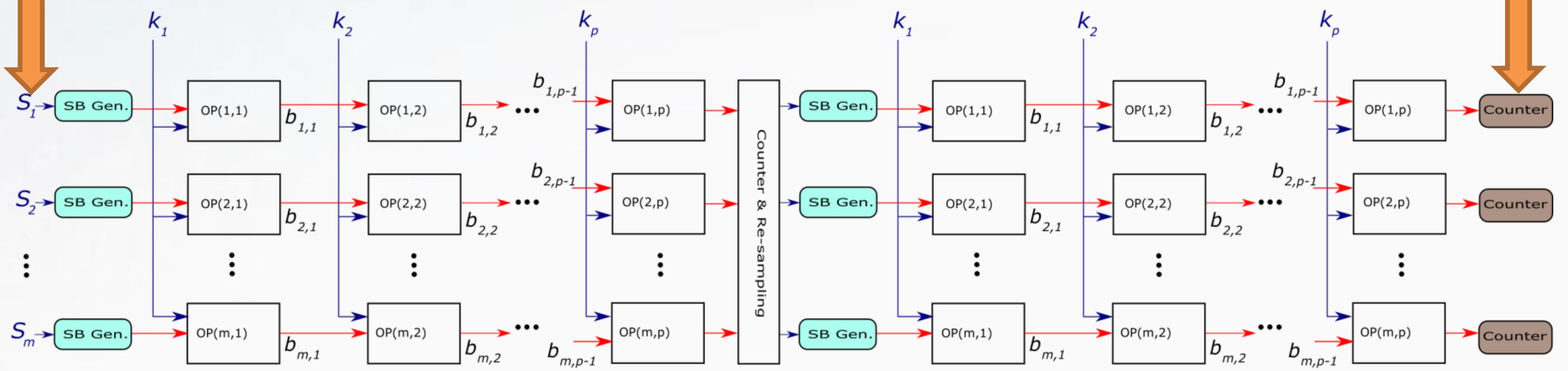
  0010000100000

$$p1 \,.\, p2 = 0.5 \,.\, 0.25 = 0.125$$

Principle of a parallel sampling machine

Priors on x_i, y_j

Posterior

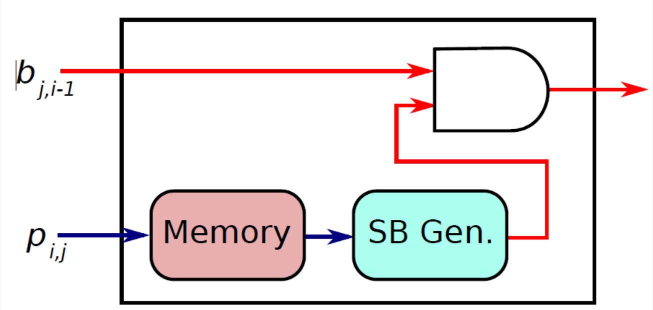


Re-sampling the stochastic bus

$$P(x_i, y_i) \propto \prod_l P(k_l | x_i, y_j)$$

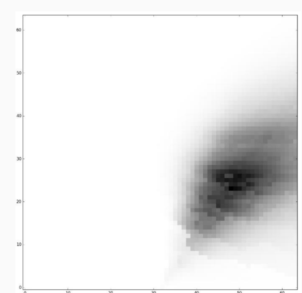
prior

evidence



(b) BM1 element

$$P(k | x_i, y_j)$$



Sound source localization (3)

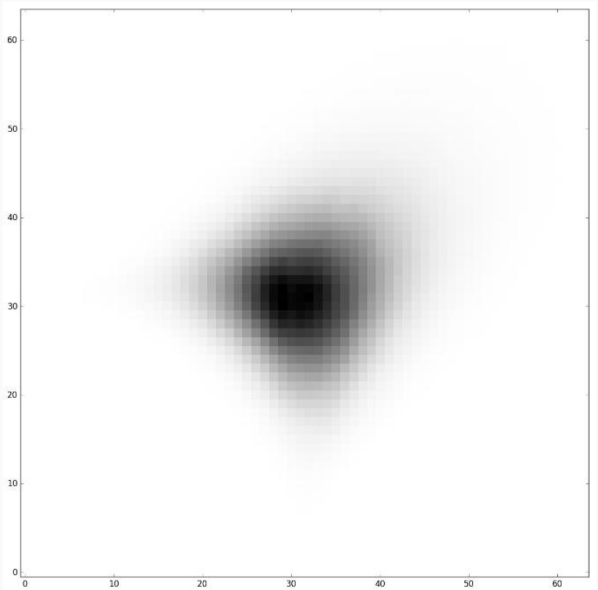
- Workflow

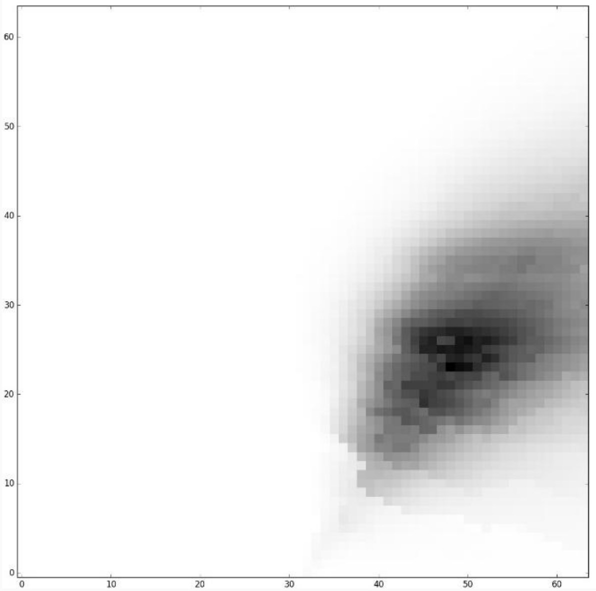
Simulation of sound waves → Feature extraction → Calculation of probability distributions → Simulation of BM1

- BM1 – Sliced with fast simulator
- Tackling the temporal dilution
  - Re-sampling of the probability distribution after a small subset of sensors

Sound source localization (4) (simulation)

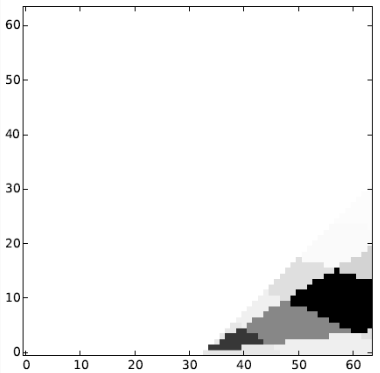
- Results after run(100000)





Future work – Source localization

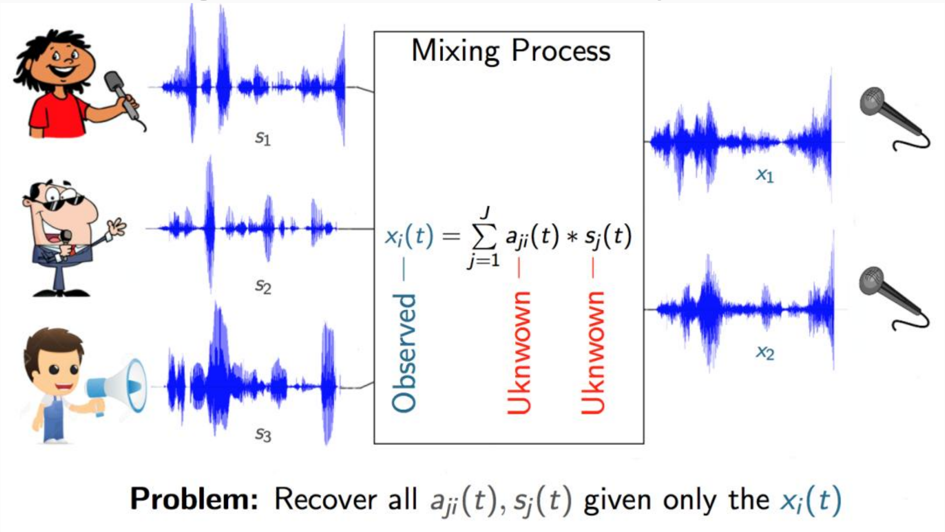
- Move to FPGA
- Remove the time-frequency domain analysis
  - Use of the Fourier transform
  - Currently done on a normal CPU



- Compression of probability distributions
- Localize a moving source using a filter

Sound source separation

- Use of sequential sampling
- Design of new algorithms for stochastic inference based on generating sets
- Planned during the second year



Future work – Source separation

- Explore new ways of sampling
  - MCMC
  - Generating sets

Industrial perspective

- Discussion with ProbaYes to launch an ambitious R&D program on stochastic Machines (3 Years -> 6M€)

Conclusion

- MicroBayes on track

The future Bayesian valley