Gas Source Localisation by Constructing Concentration Gridmaps with a Mobile Robot

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Contents

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1 Motivation – Mobile Nose Research

- Mobile Nose - Research

  - physical properties of gas transport

  - understand how animals use odours to navigate

- Mobile Nose - Interests

  - gas distribution mapping

  - gas source localisation

2 | Gas Source Localisation – Main Problems
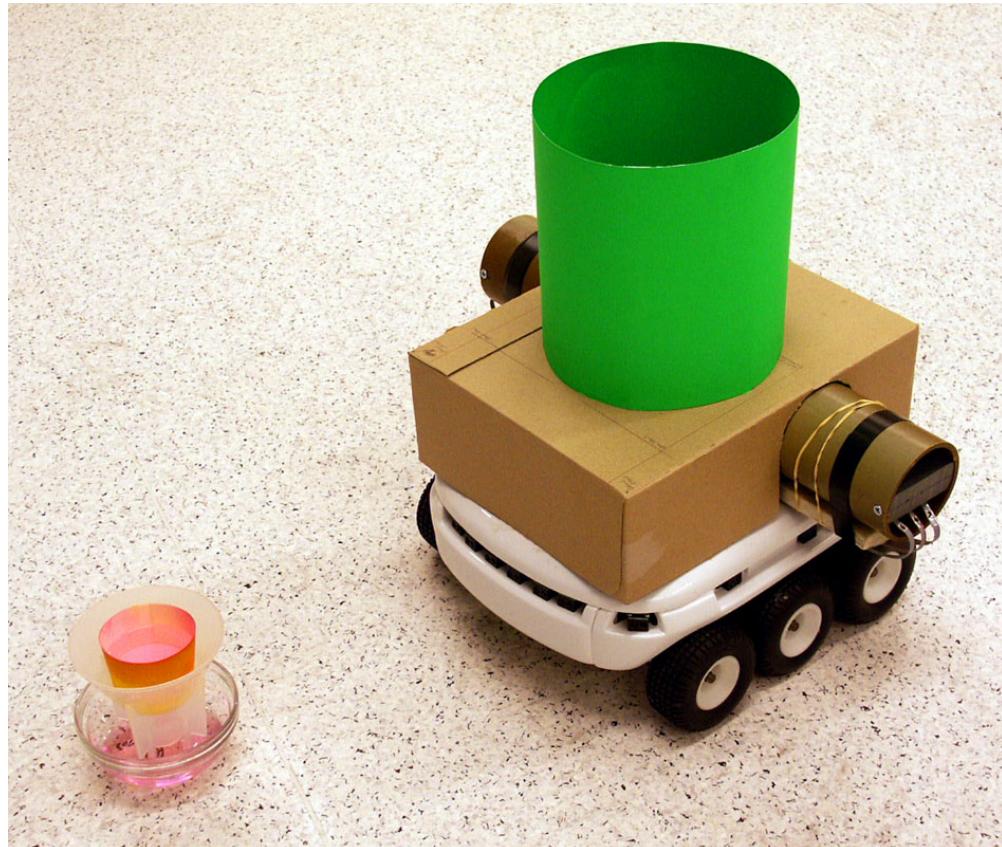
■ Delayed Response

■ $\tau_r \approx 1.8$ s

■ Delayed Recovery

■ $\tau_d^{(fans)} \approx 11.1$ s
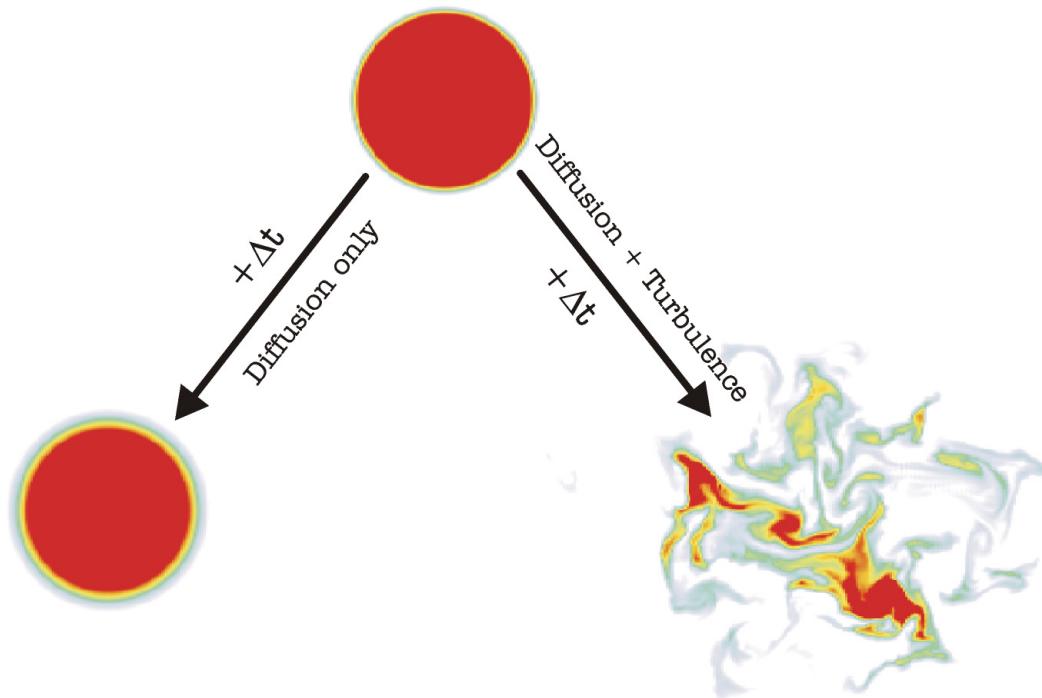
"memory effect"

2 Gas Source Localisation – Main Problems

■ Instantaneous Distribution ≠ Average Distribution

Smyth & Moum 2001

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# 3 Gridmaps vs. Concentration Gridmaps
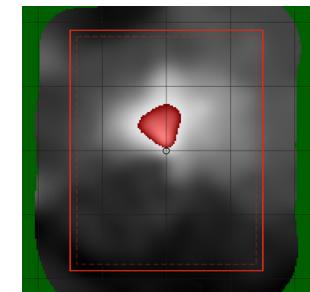
▌ **Occupancy Gridmap**

   ▌ cells represent the belief that an area is occupied

   ▌ considerable overlap between single measurements

▌ **Concentration Gridmap**

   ▌ cells represent the relative concentration on average

   ▌ measurements cover a very small area

   ▌ measurements depend on the past

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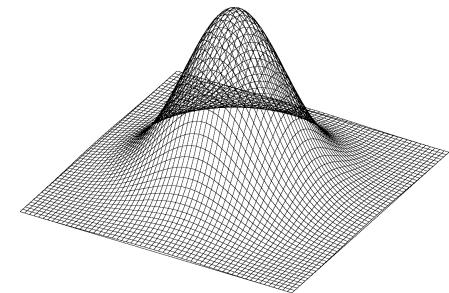
❚ Extrapolate on the Measurements

  ❚ Gaussian density function

$$f\left(\vec{x}\right) = \frac{1}{2\,\pi\,\sigma^2}\;e^{-\frac{\vec{x}^2}{2\,\sigma^2}}$$

❚ Justification

  ❚ smooth time-constant structures of the gas distribution

 ❚ implicit integration due to the sensor characteristics
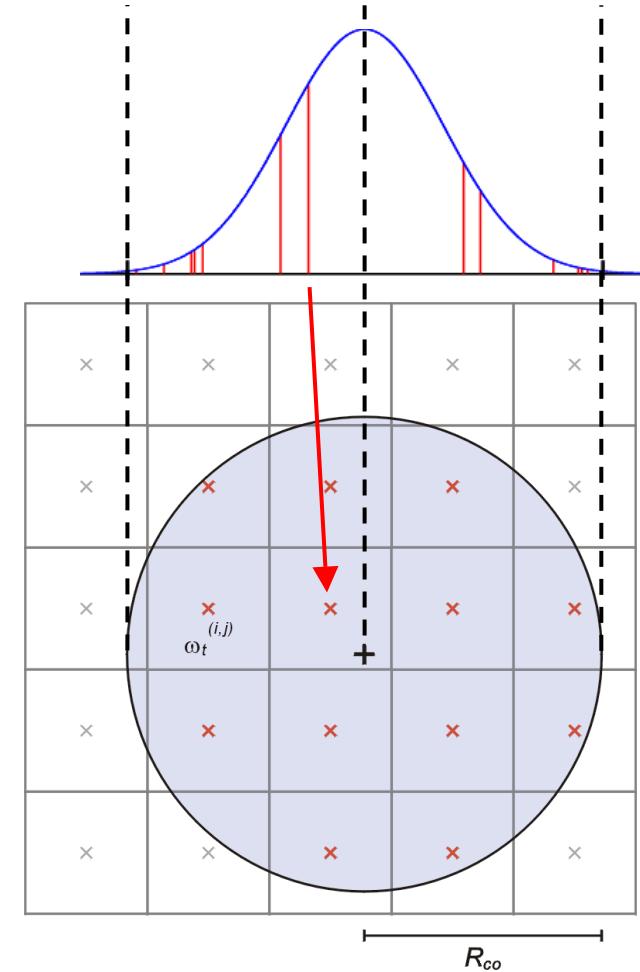
3 Creating Concentration Gridmaps

▮ Displacement of Cells

$$\vec{\delta}_t^{(i,j)} = \vec{x}^{(i,j)} - \vec{x}_t$$

▮ Determine Weightings

$$\omega_t^{(i,j)} = \begin{cases} f\left(\vec{\delta}_t^{(i,j)}\right) & : \delta_t^{(i,j)} \le R_{co} \\ 0 & : \delta_t^{(i,j)} > R_{co} \end{cases}$$

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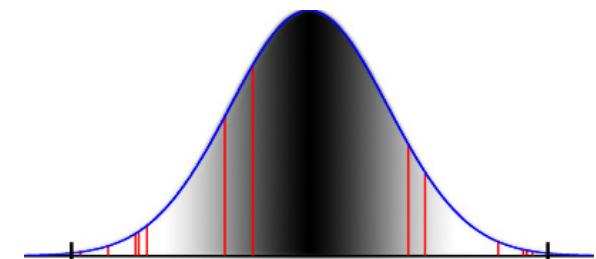
3 Creating Concentration Gridmaps

■ Update Weighting Table
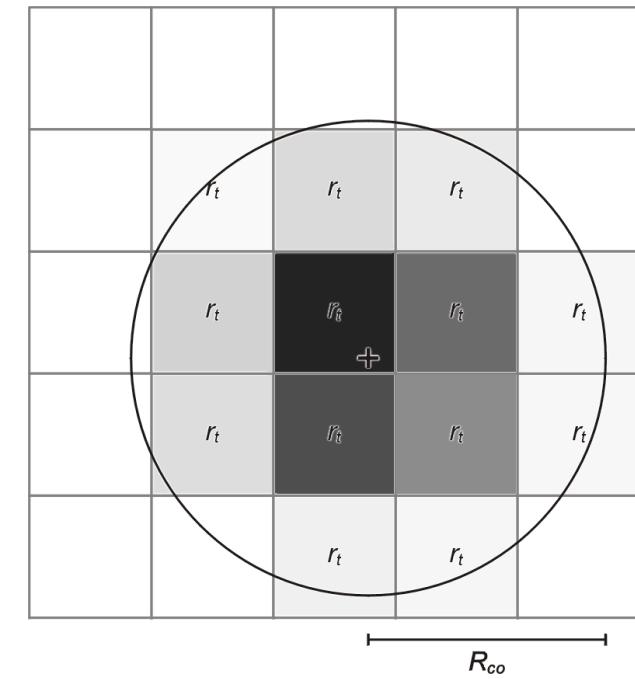
$$W_t^{(i,j)} = W_{t-1}^{(i,j)} + \omega_t^{(i,j)}$$

■ Update Weighted Readings

$$\text{WR}_t^{(i,j)} = \text{WR}_{t-1}^{(i,j)} + r_t\,\omega_t^{(i,j)}$$

$$r_t = \frac{R_t - R_{\min}}{R_{\max} - R_{\min}}$$

R_{co}

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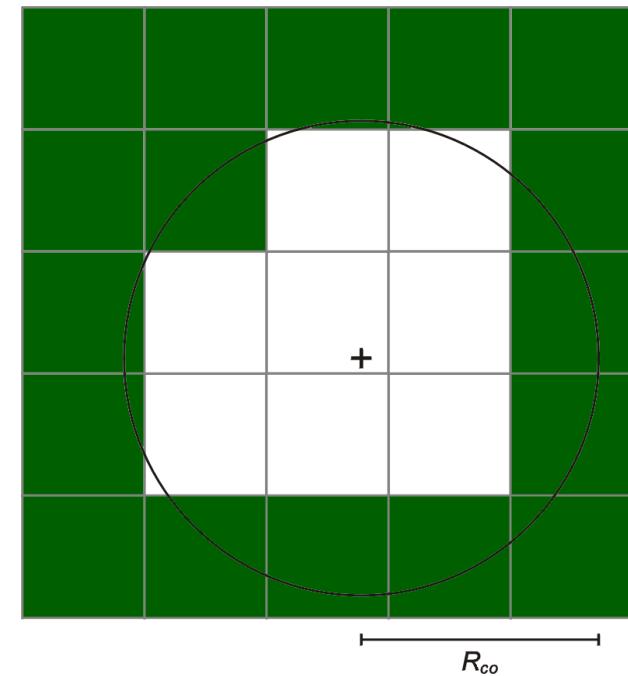
3 Creating Concentration Gridmaps

Update Cells

$$c_t^{(i,j)} = \frac{WR_t^{(i,j)}}{W_t^{(i,j)}} \quad : \quad W_t^{(i,j)} \geq W_{\min}$$
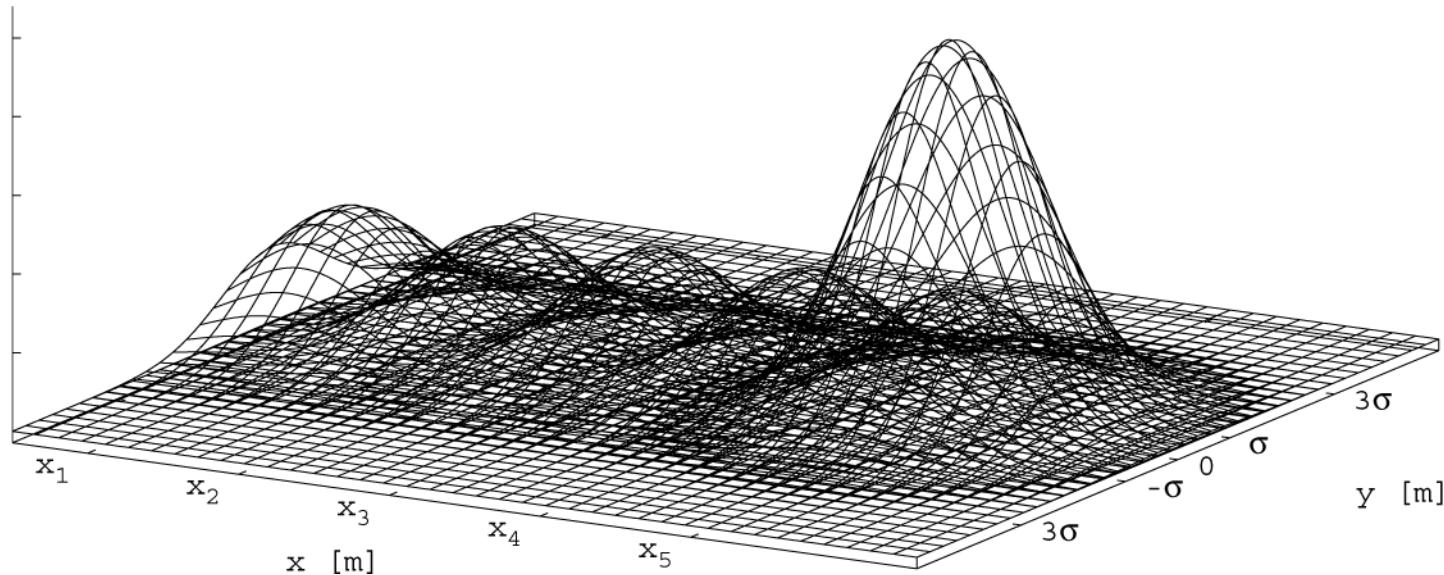
Next Timestep
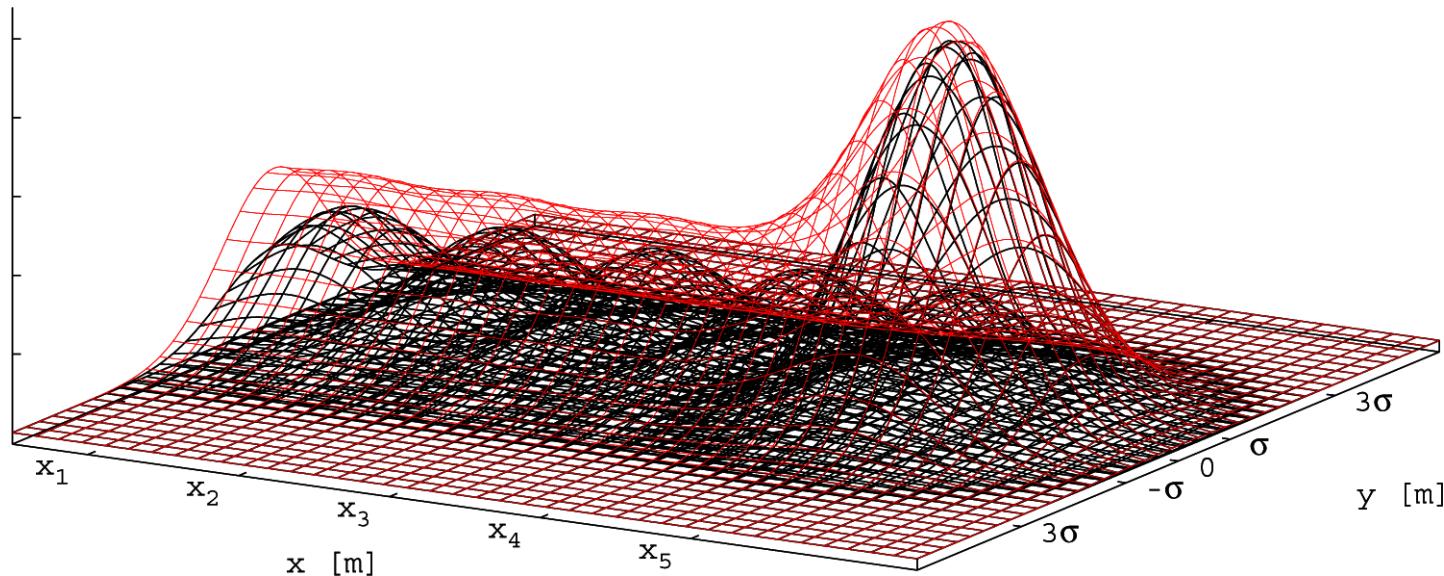
R_{co}

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■ Extrapolation on Sequential Readings

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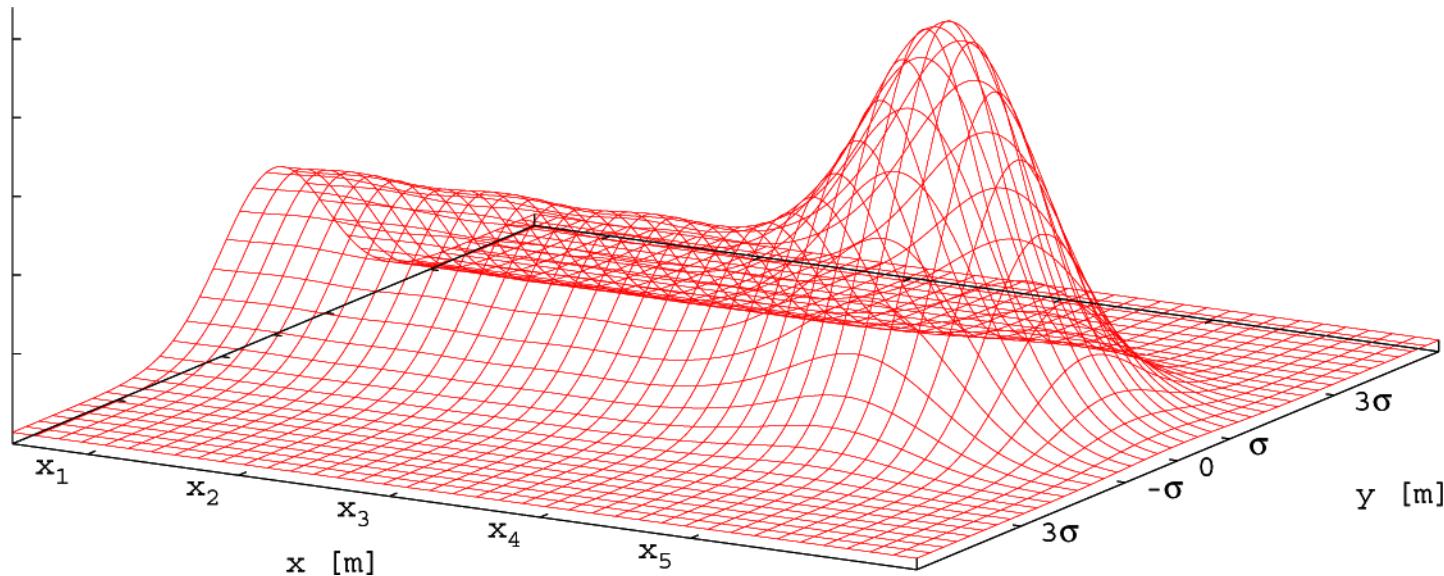
■ Extrapolation on Sequential Readings

Extrapolation on Sequential Readings

- Stereo Architecture
  - 2 equivalent sets
    - Figaro TGS 2600
    - Figaro TGS 2610
   - Figaro TGS 2620
  - 40 cm separation
  - suction fans
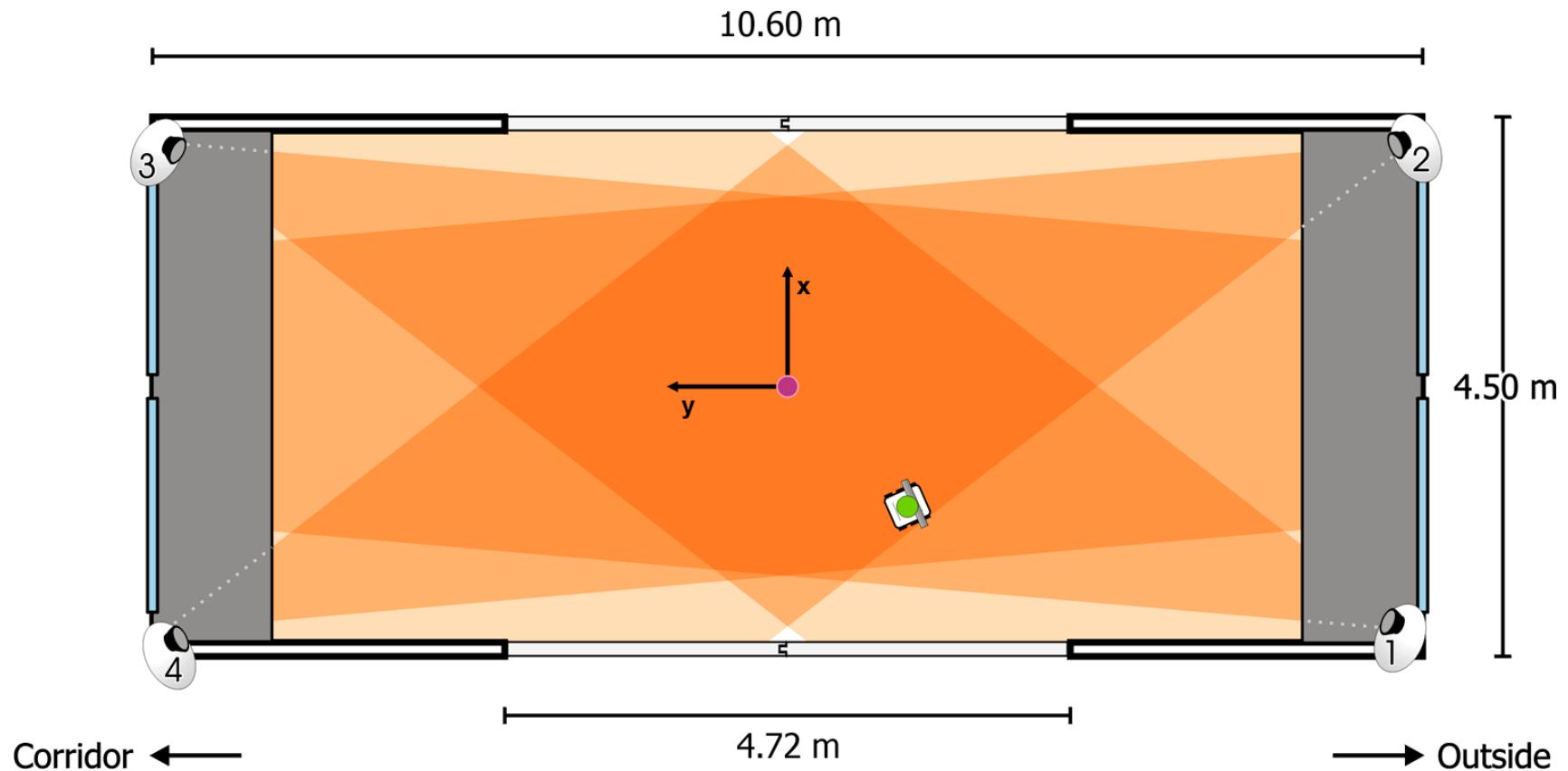
30 cm

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4 Experimental Setup – Environment
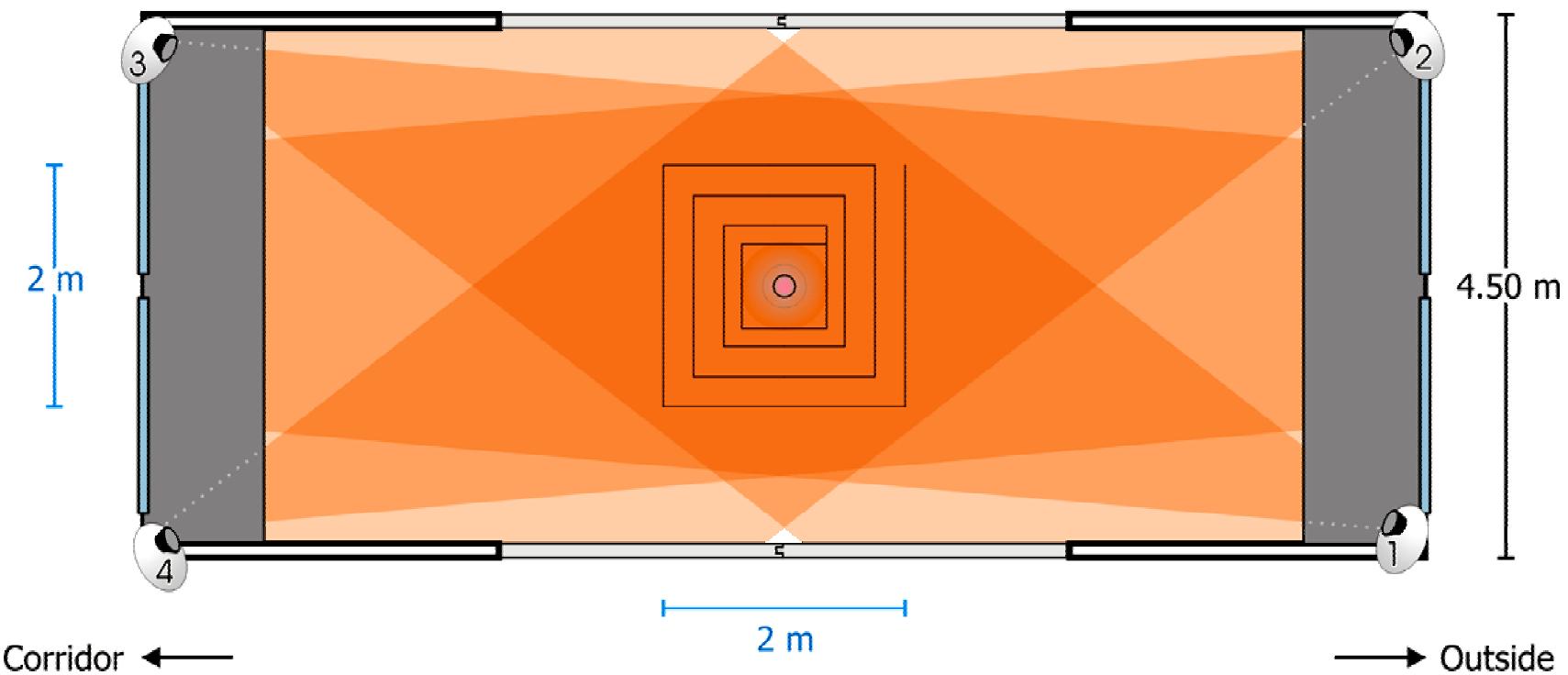
- Laboratory Room, No Air Condition
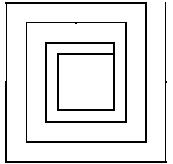
10.60 m

4.50 m

4.72 m

Corridor ← → Outside

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5 Gas Source Localisation

■ Predefinded Path – Rectangular Spiral


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5 Gas Source Localisation

- Predefinded Path – Rectangular Spiral
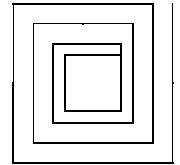
| 2003 / 06 / 02 | 2003 / 06 / 03 | 2003 / 06 / 04 |
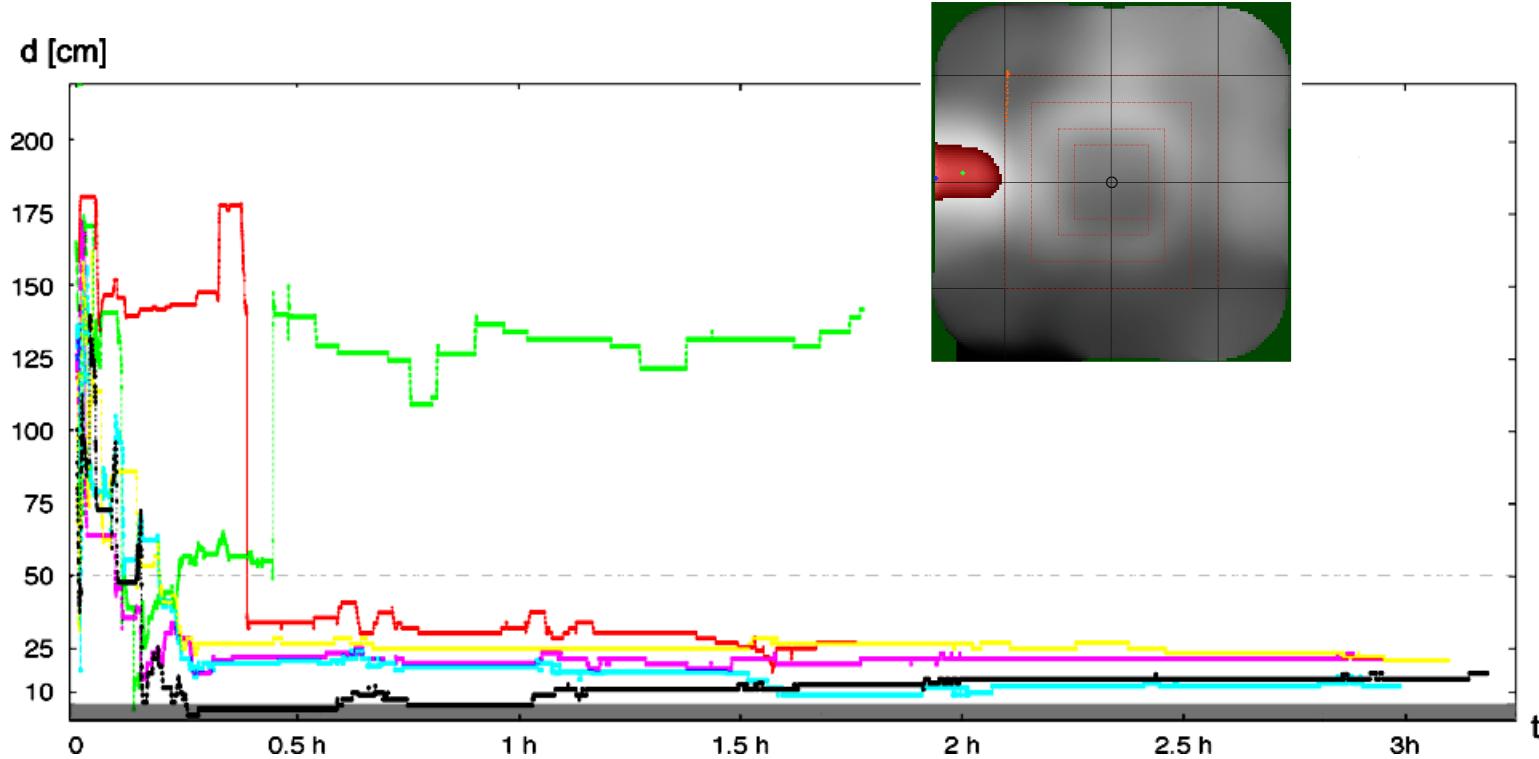
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5 Gas Source Localisation

Predefinded Path – Rectangular Spiral
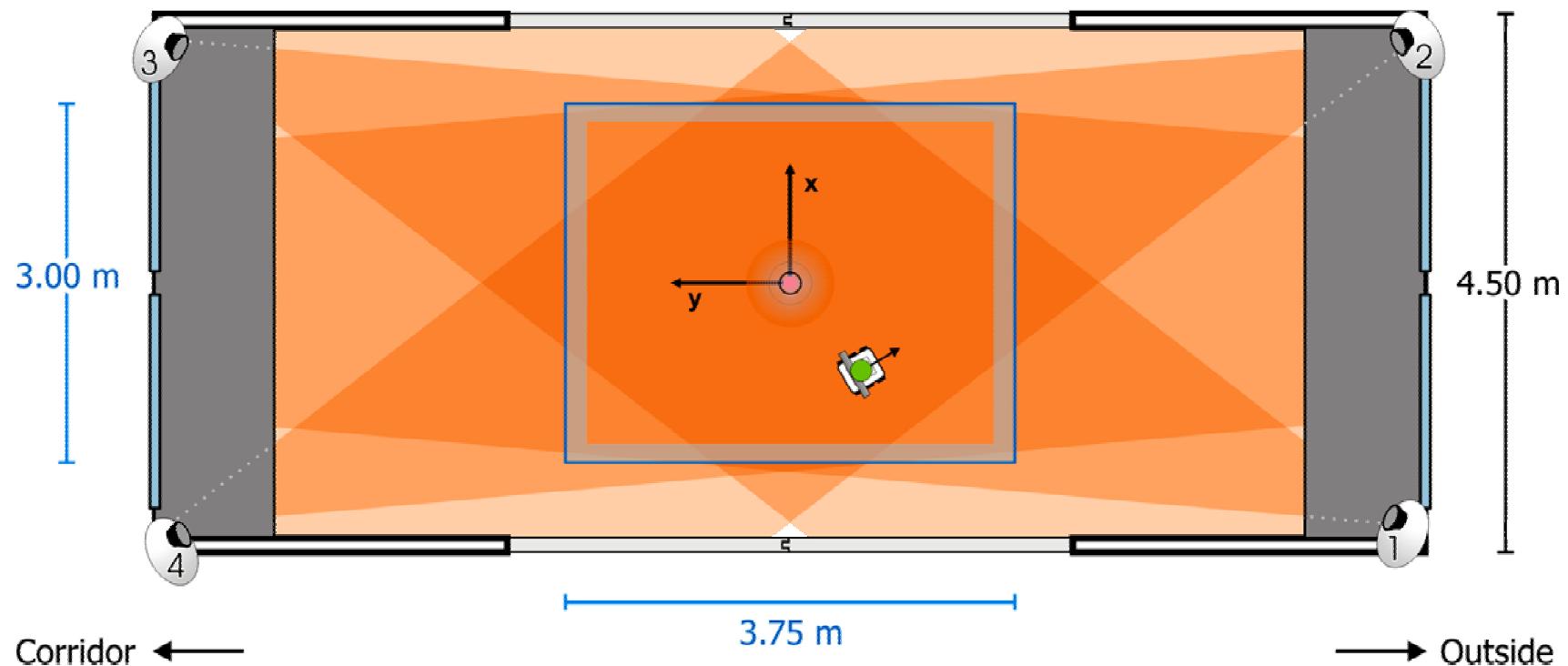

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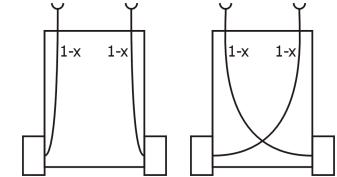
5 Gas Source Localisation

Reactive Strategy – Braitenberg Vehicle

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Reactive Strategy – Braitenberg Vehicle

2002 / 12 / 01

2002 / 12 / 01

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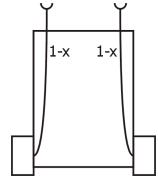
Reactive Strategy – Braitenberg Vehicle
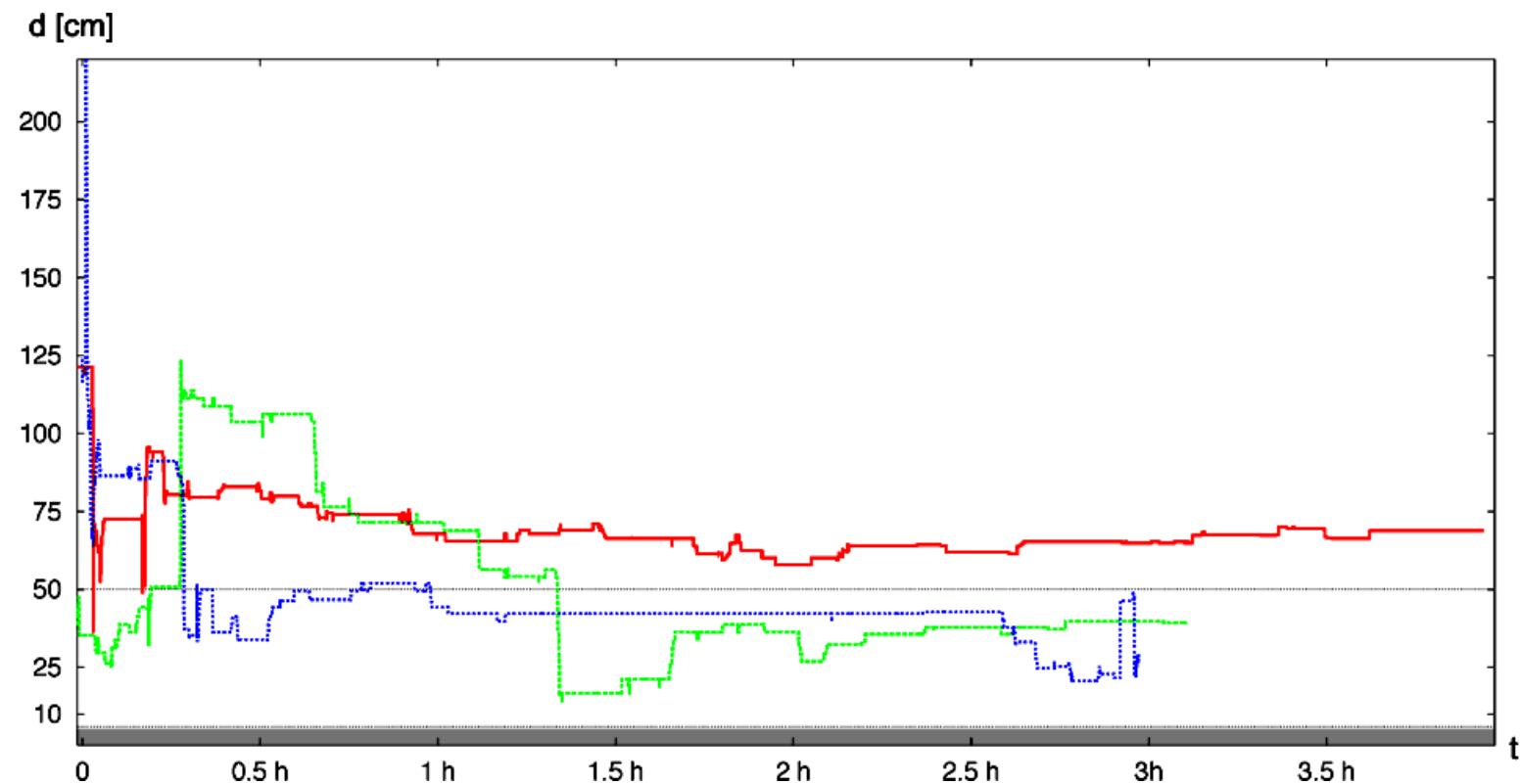
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5 Gas Source Localisation
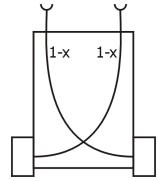
■ Braitenberg Vehicle – PL – Source in the Middle

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- Braitenberg Vehicle – EL – Source in the Middle

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6 Conclusions

- **new algorithm to create concentration gridmaps**

  - shows time-invariant structures of gas distributions

  - stabilises after ~ 30 min.

  - overcomes the problem of little overlap of measurements

  - takes into account the „memory effect"

- **localisation facility**

  - max. concentration provides good estimate

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Thank you!