Suppression of shock based errors

with gravity related endoscopic image rectification

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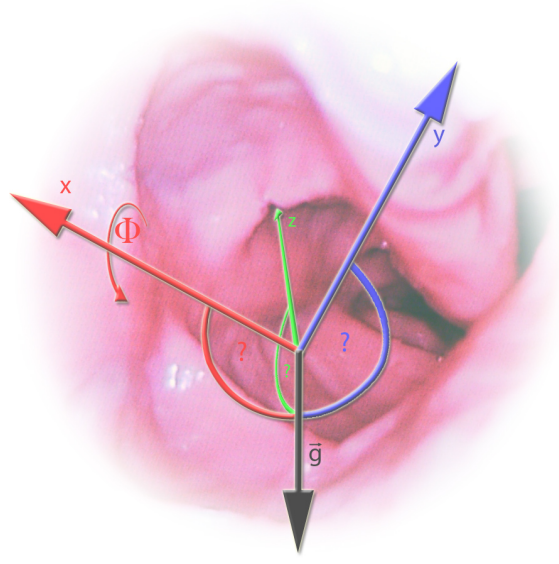
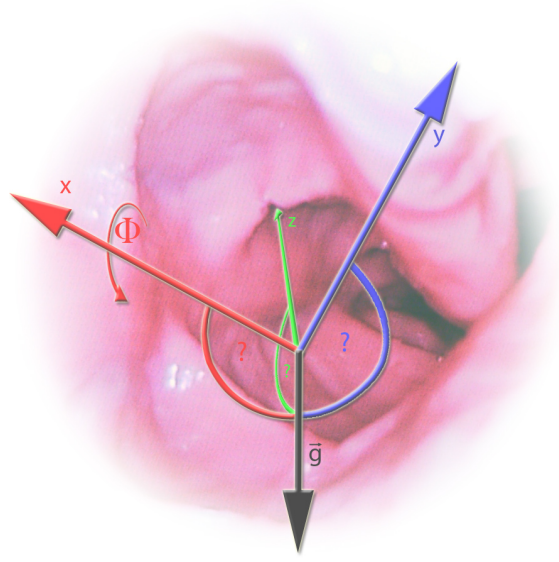
Content



Overview

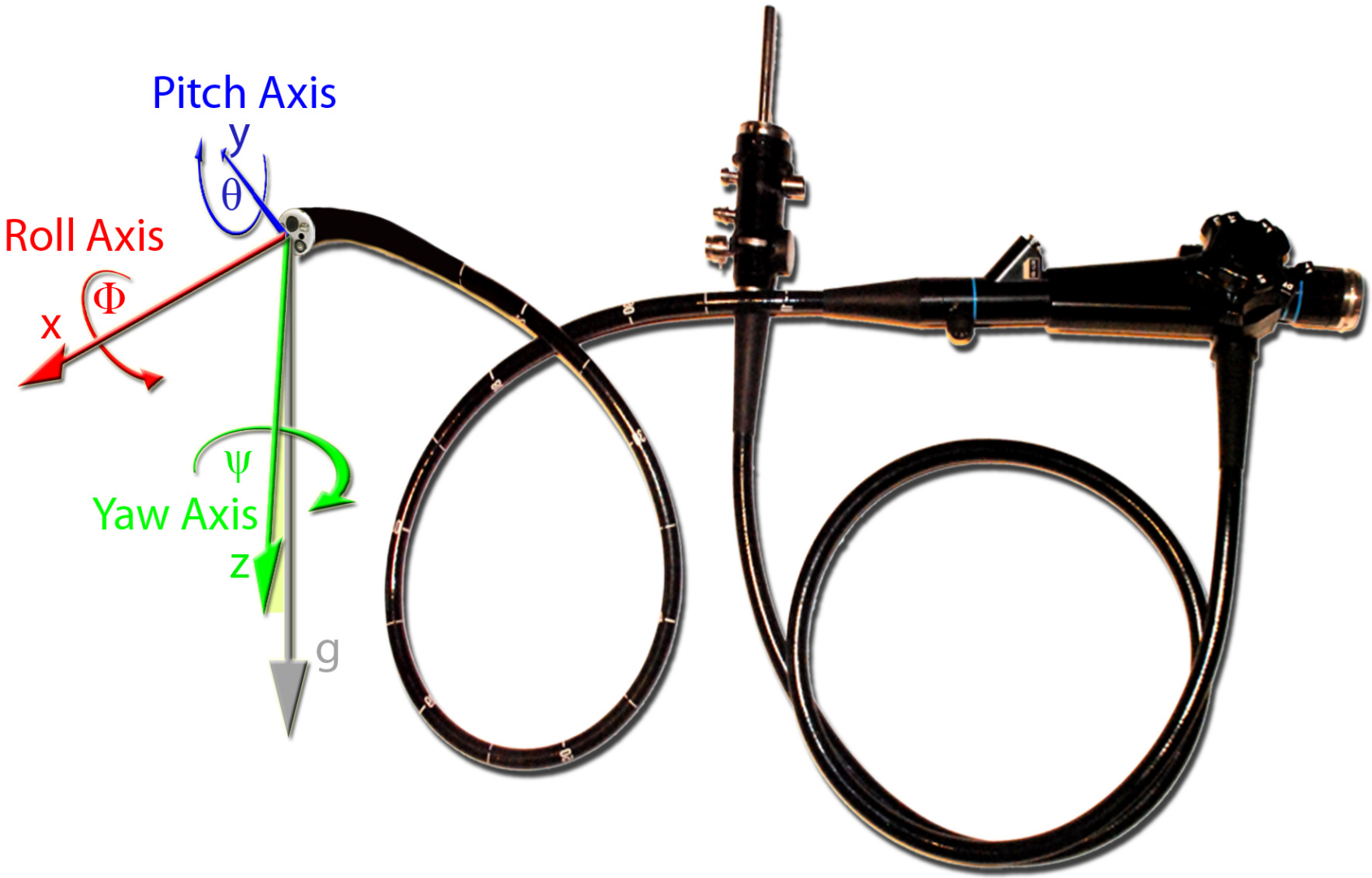


Problem of unknown image orientation

with flexible endoscopy

Roll Pitch Yaw description

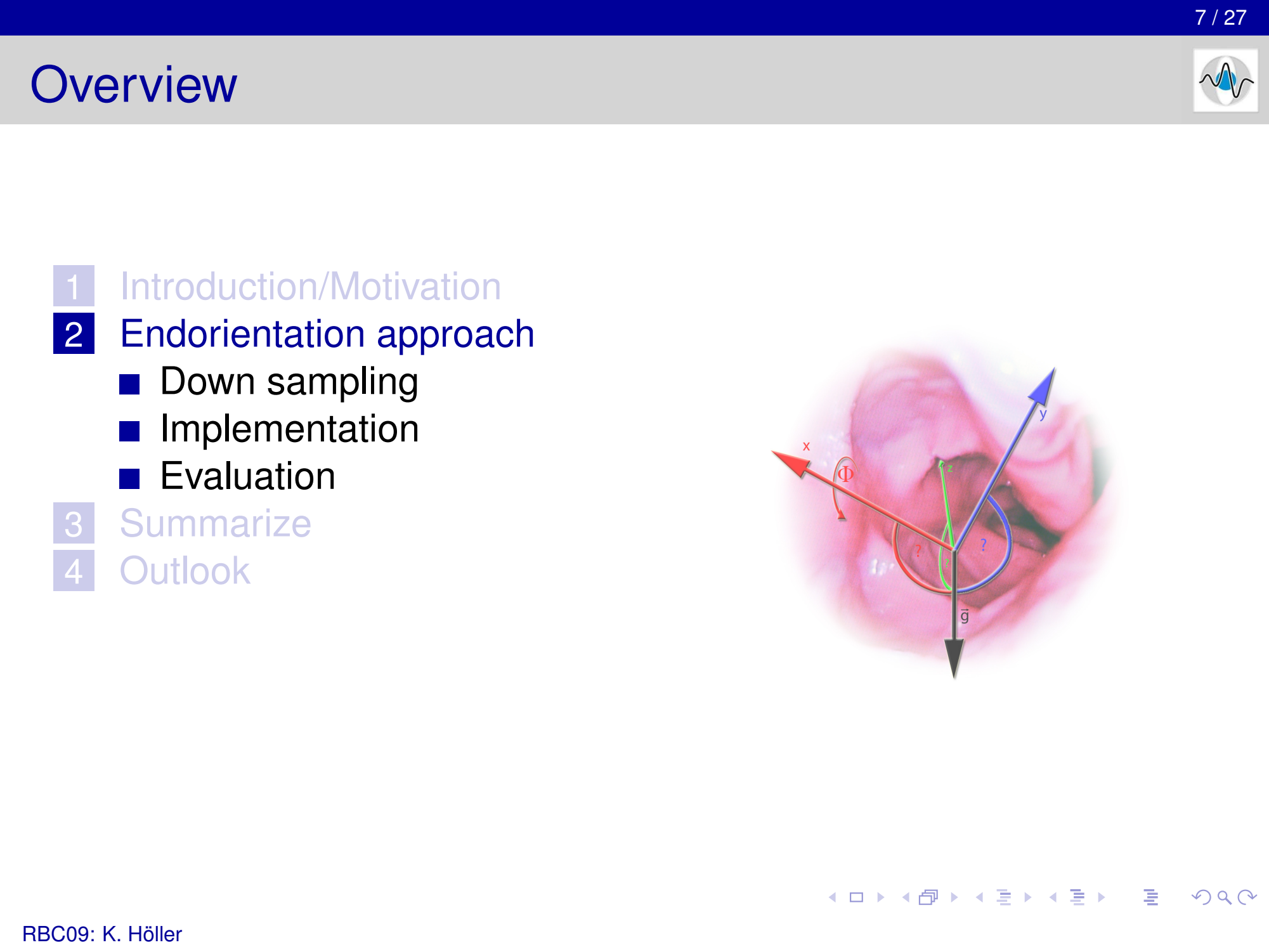
for endoscopic orientation



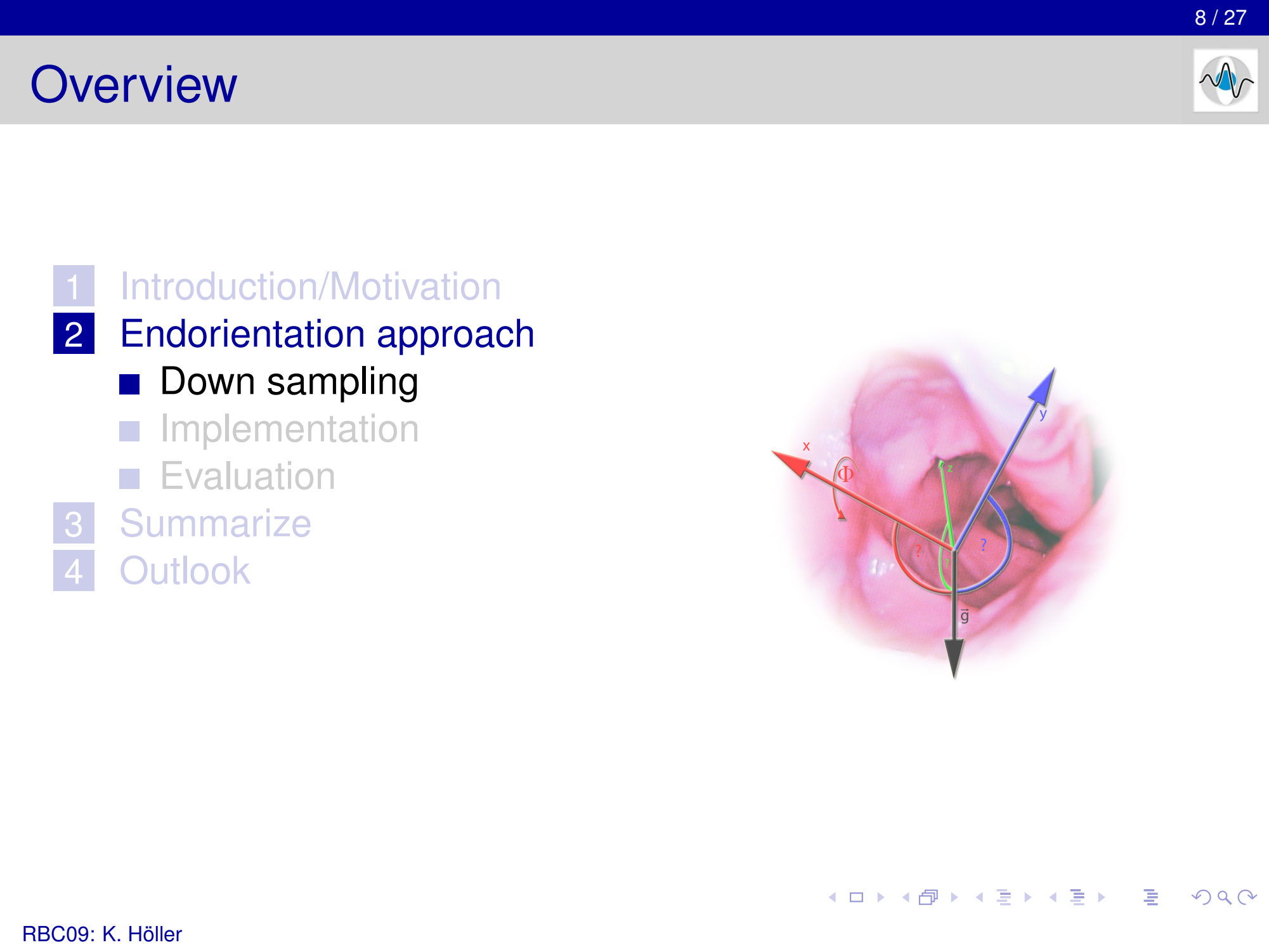
Evaluation prototype

external sensor on endoscope's tip

Overview

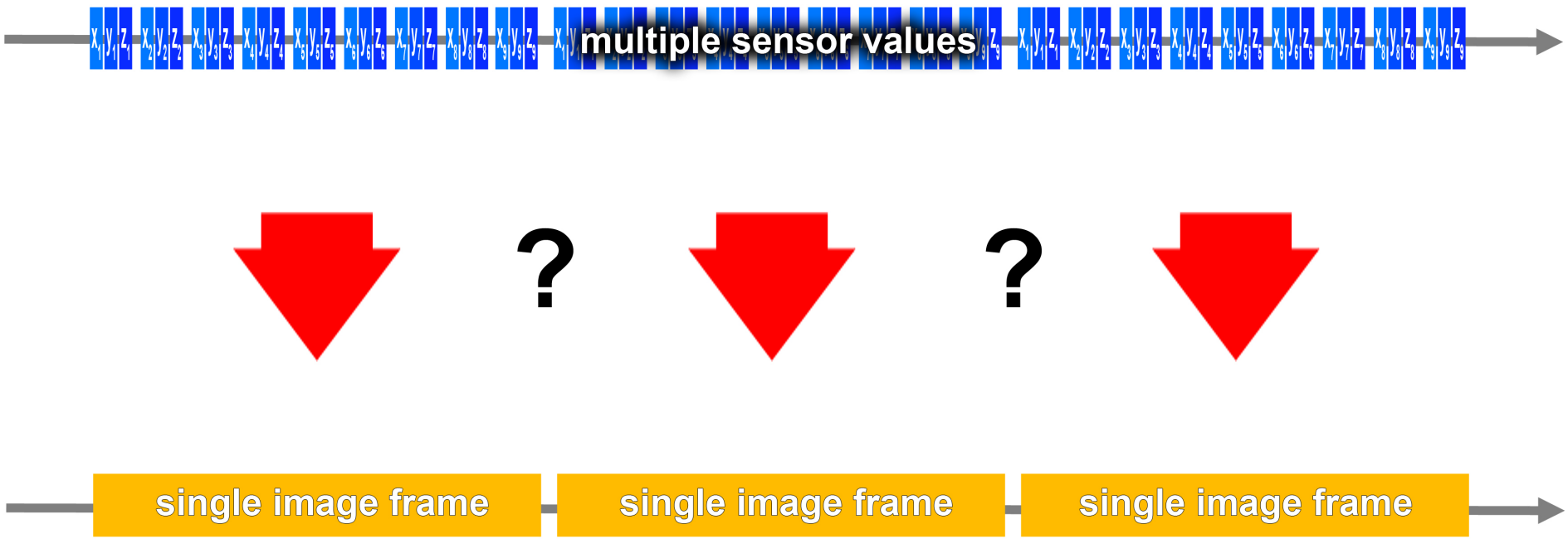


Overview



Down sampling and peak filtering algorithm

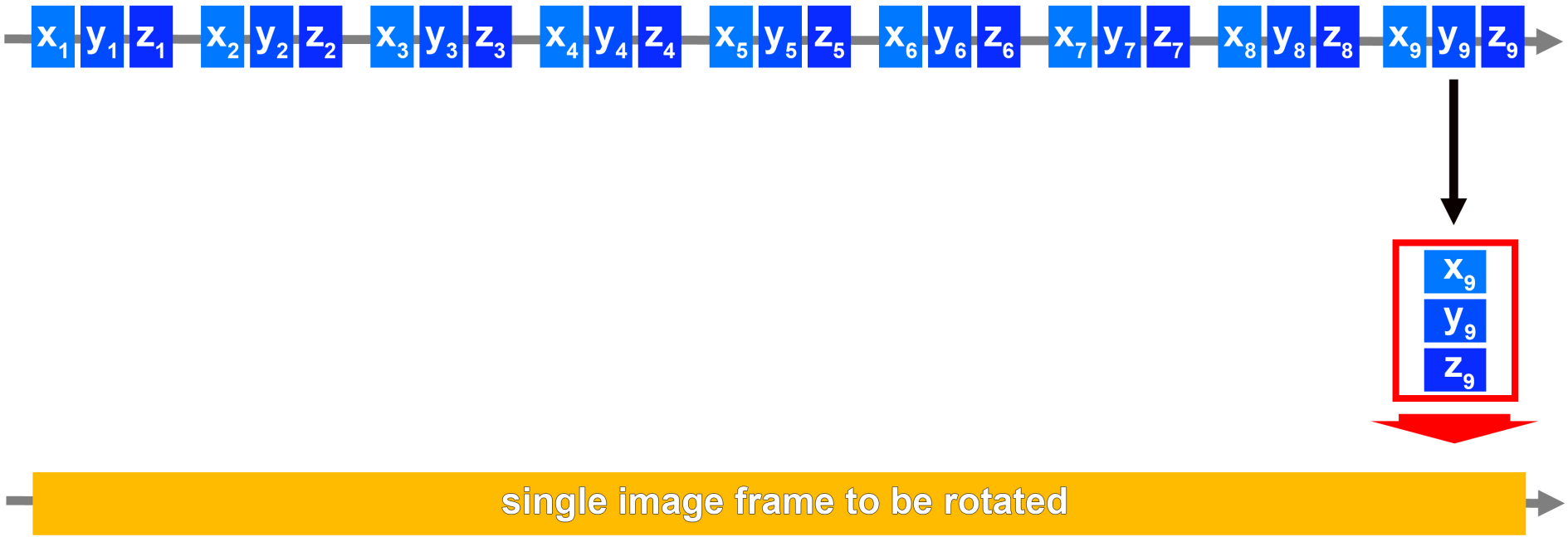
Multiple sensor values during a single image frame



Down sampling:
Different possible approaches

Down sampling and peak filtering algorithm

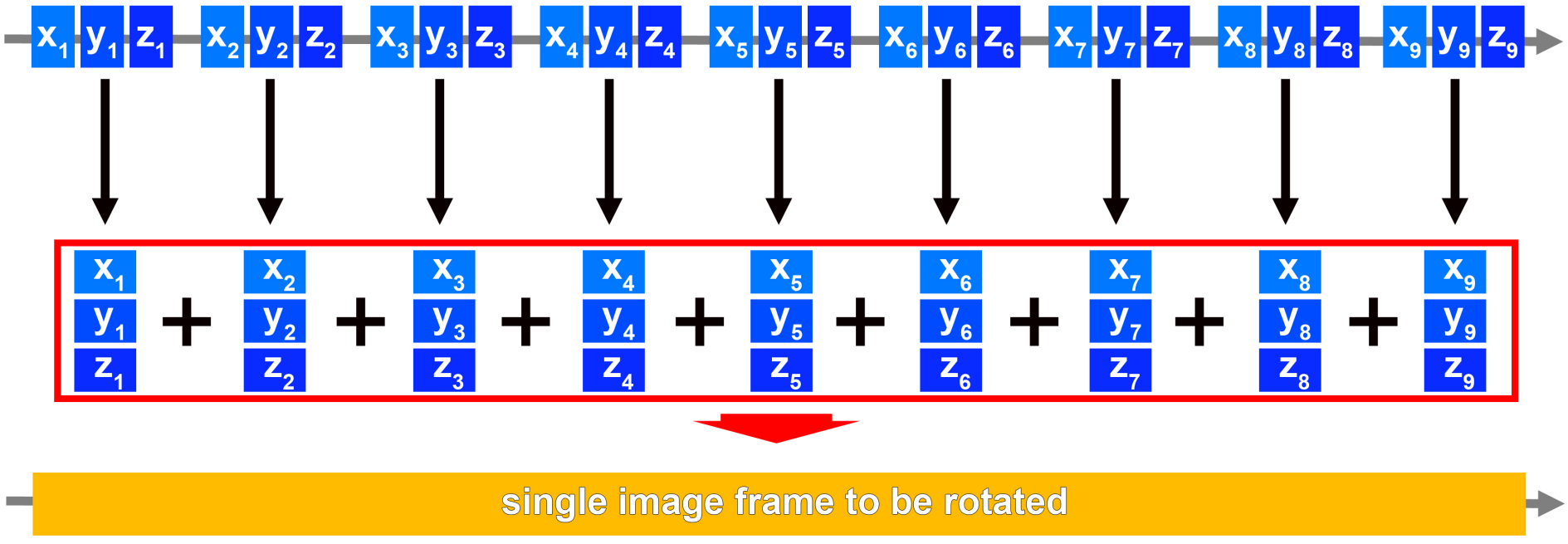
Choose last triple value to rotate new image frame



Last Triple:
- \+ newest sensor value
- \- no noise reduction, high movement influence

Down sampling and peak filtering algorithm

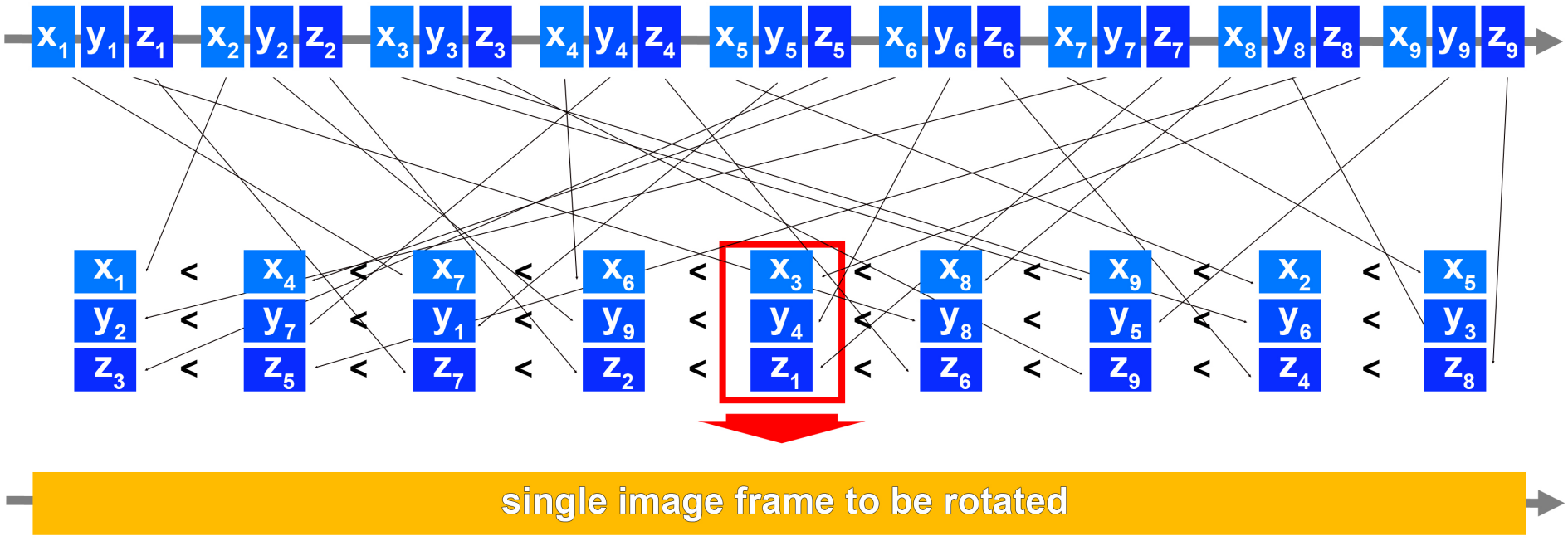
Average all sensor triples to rotate new image frame



Mean values:
- \+ noise reduction
- \- movement influence

Down sampling and peak filtering algorithm

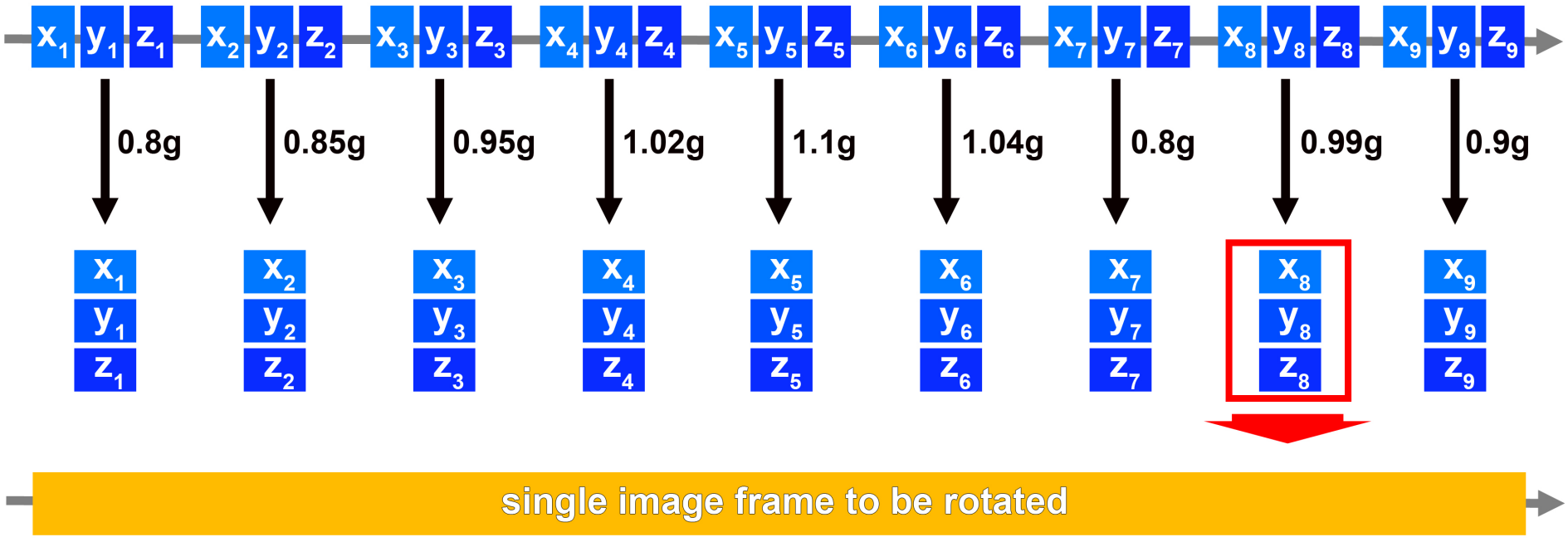
Choose median of each sensor axis to rotate new image frame



Median of each axis:
+ noise reduction
- distortion

Down sampling and peak filtering algorithm

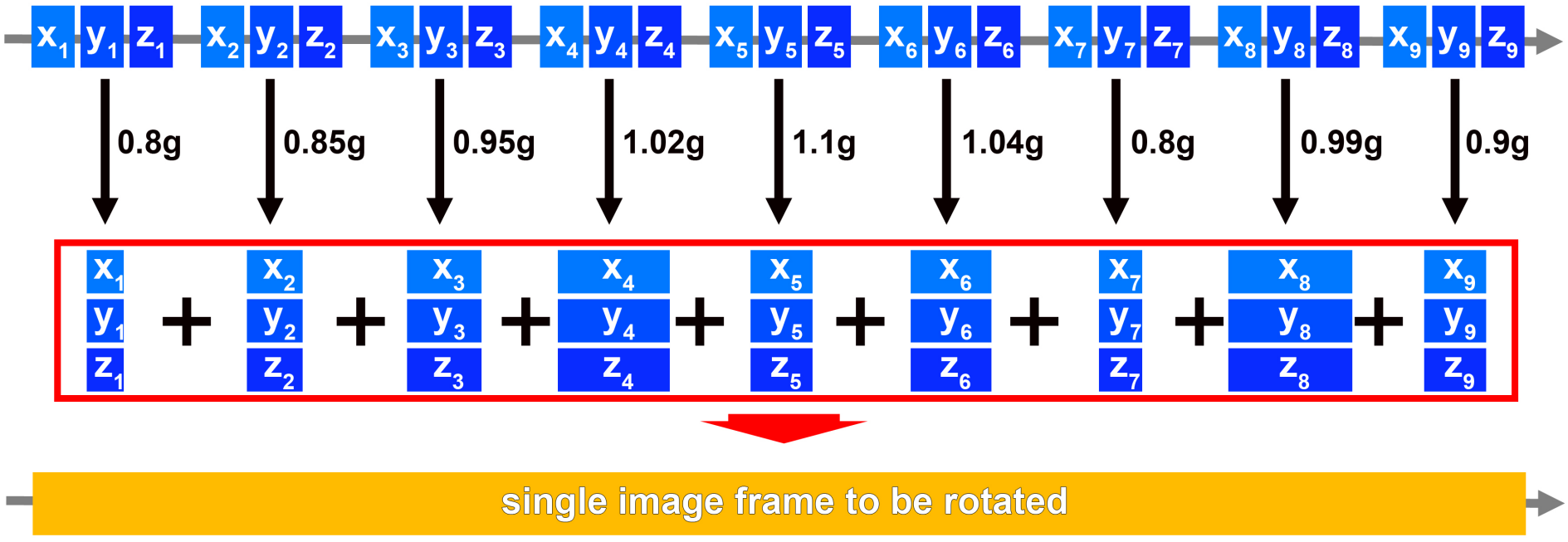
Choose best triple to rotate new image frame



Best Triple:
- \+ less movement influence
- \- no noise reduction

Down sampling and peak filtering algorithm

Add weighted values to rotate new image frame



Weighted Sum:
- \+ less movement influence
- \+ noise reduction

Down sampling

by summing up weighted samples

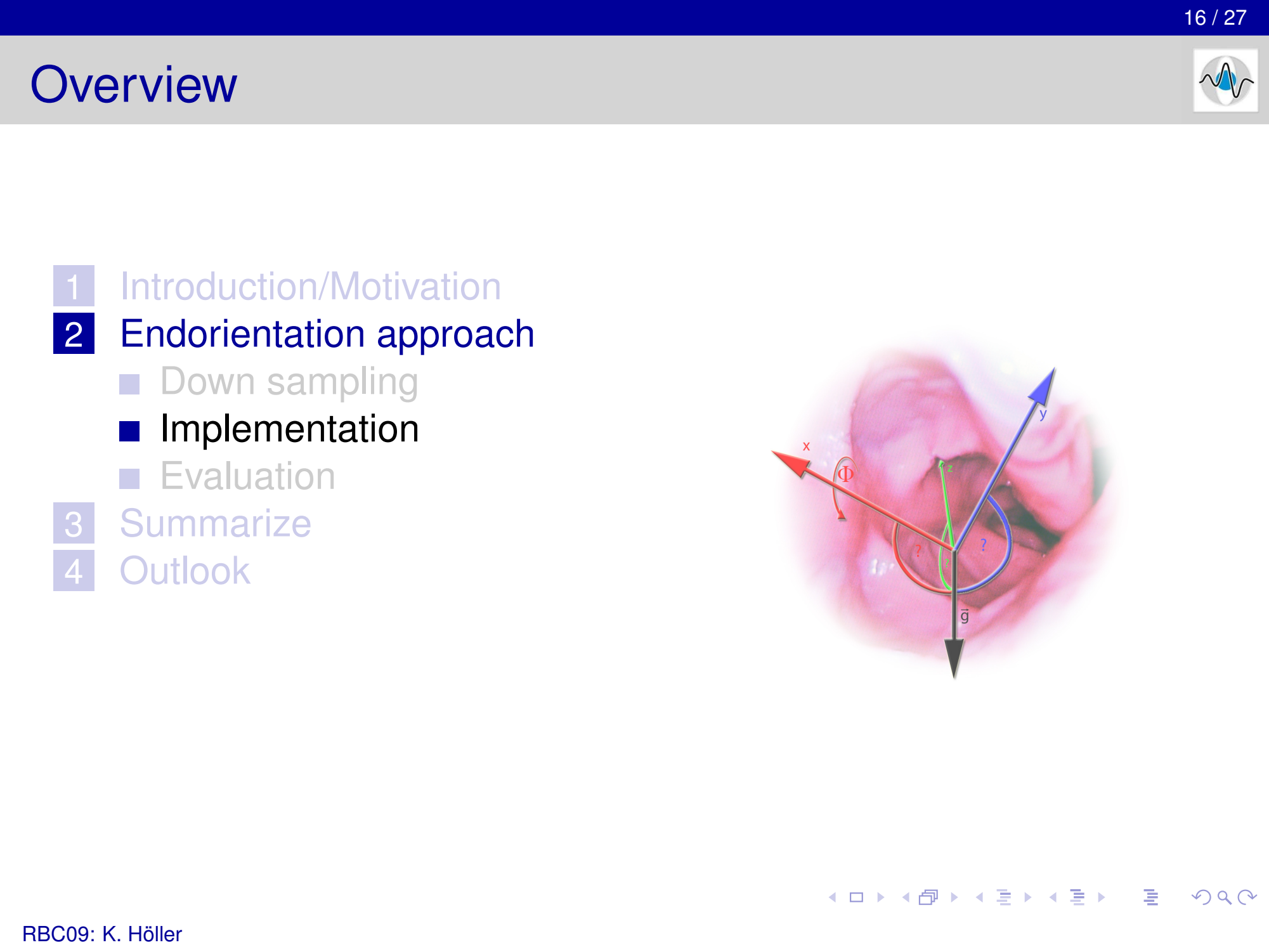
All n sensor values F_{x_i}, F_{y_i} and F_{z_i} within an image frame with $i = 1, ..., n$ are summed up and weighted with a factor w_i with maximal weight $\frac{1}{w_0}$:

$$w_i = \frac{1}{w_0 + |\sqrt{F_{x_i}^2 + F_{y_i}^2 + F_{z_i}^2} - g|} \tag{1}$$

Afterwards the sum has to be normalized by the sum of all weighting factors w_i:

$$\begin{pmatrix} F_x \\ F_y \\ F_z \end{pmatrix} = \sum_{i=1}^{n} \left(\begin{pmatrix} F_{x_i} \\ F_{y_i} \\ F_{z_i} \end{pmatrix} \cdot w_i \right) \cdot \left(\sum_{i=1}^{n} (w_i) \right)^{-1} \tag{2}$$

Overview



Endorientation algorithm

Block diagram

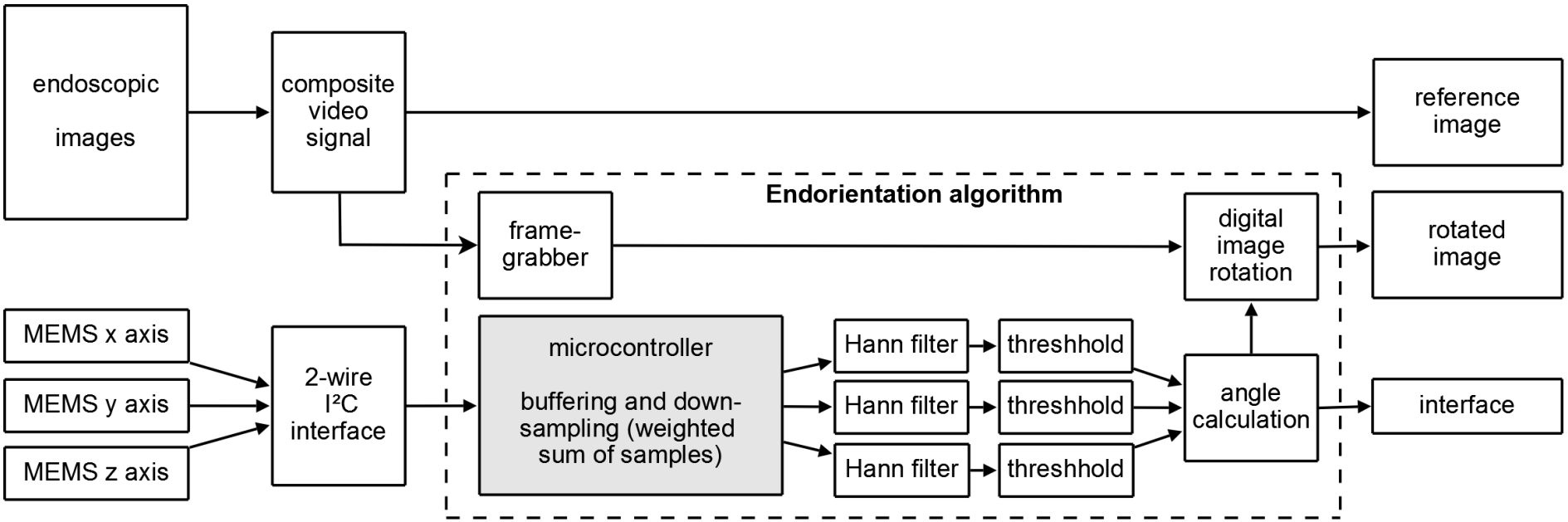


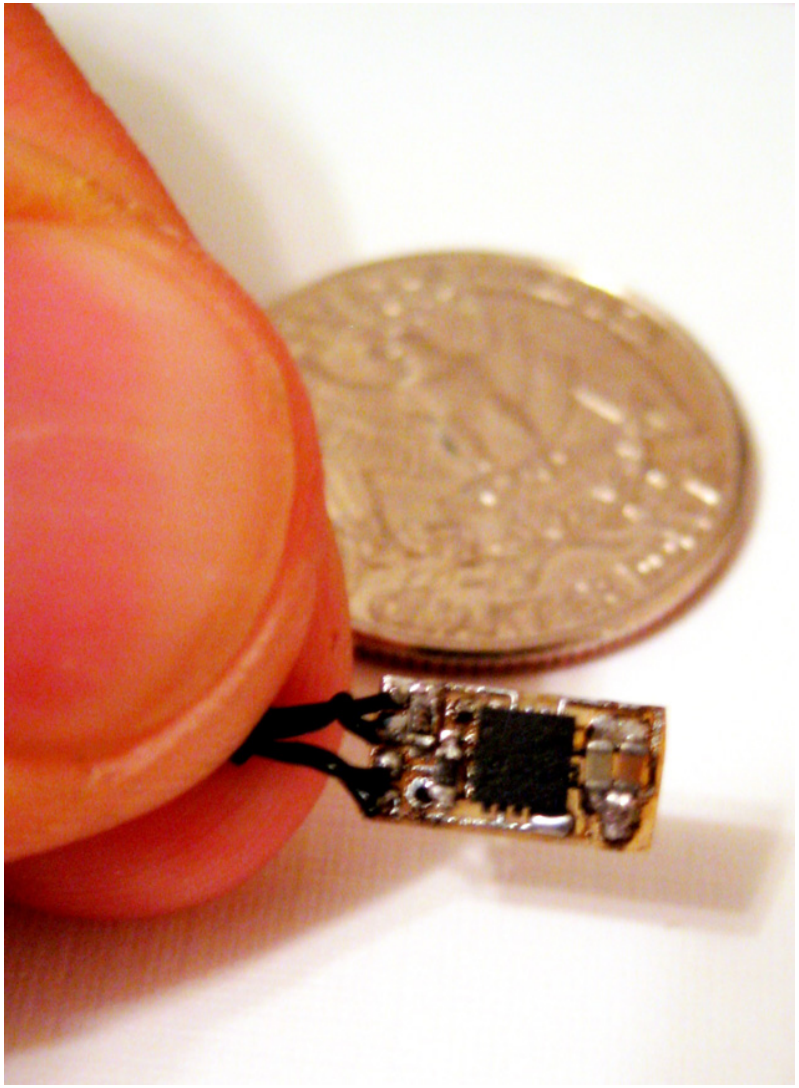
Figure: Principle of Endorientation algorithm

Small Prototype

Solution for loss of spatial orientation

Circuit board with MEMS chip STM LIS331DL for acceleration measurement, 10uF/100nF SMD capacitors for power supply HF denoising and 4k7 SMD resistors for I^2C adaption

- 3-axis MEMS accelerometer
- 0603 capacitors
- range $\pm 2.3g$
- overall size 5x8mm
- communication via two-wire I^2C interface



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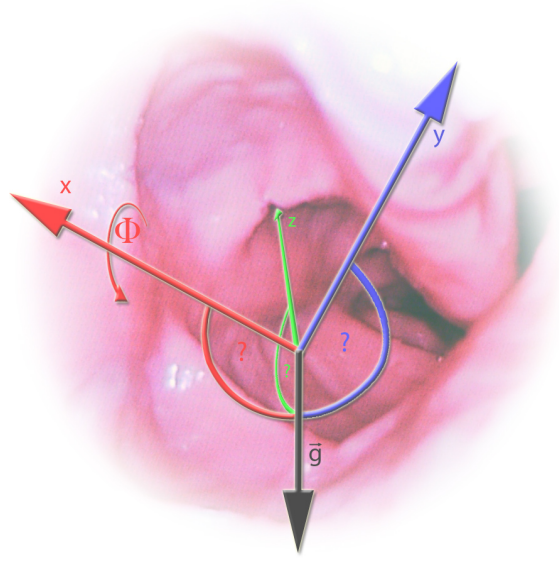


First results

Software solution

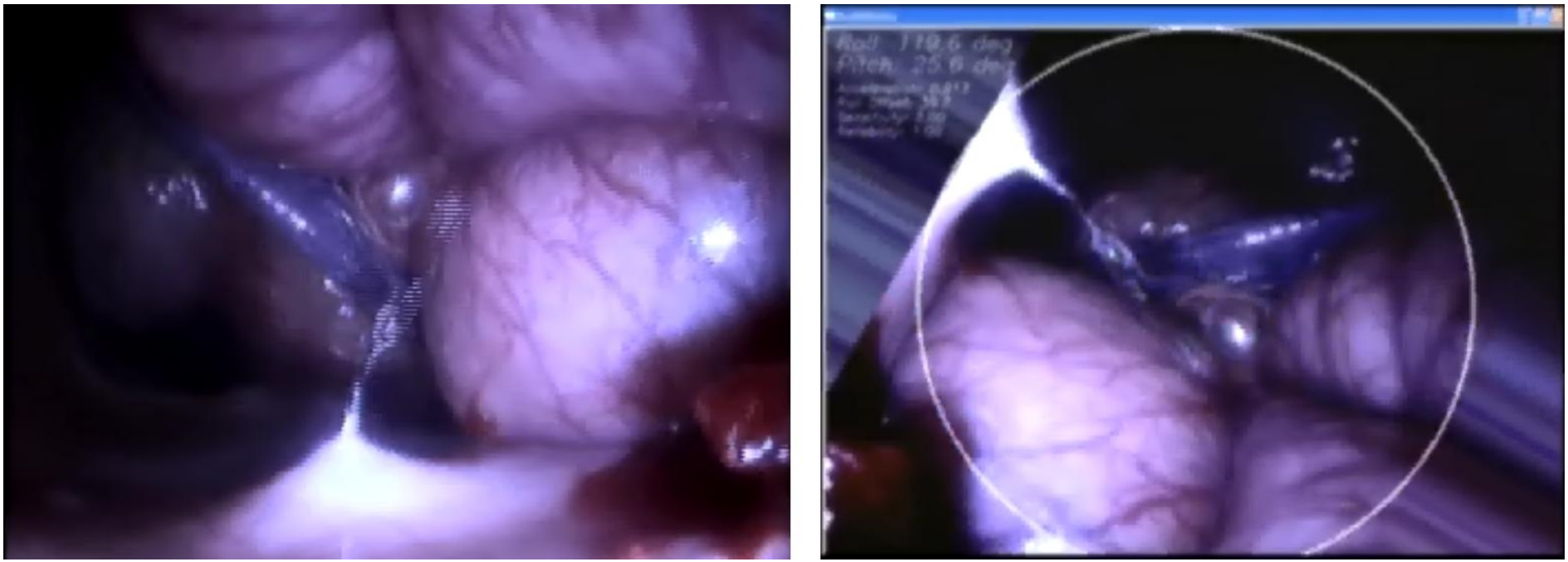
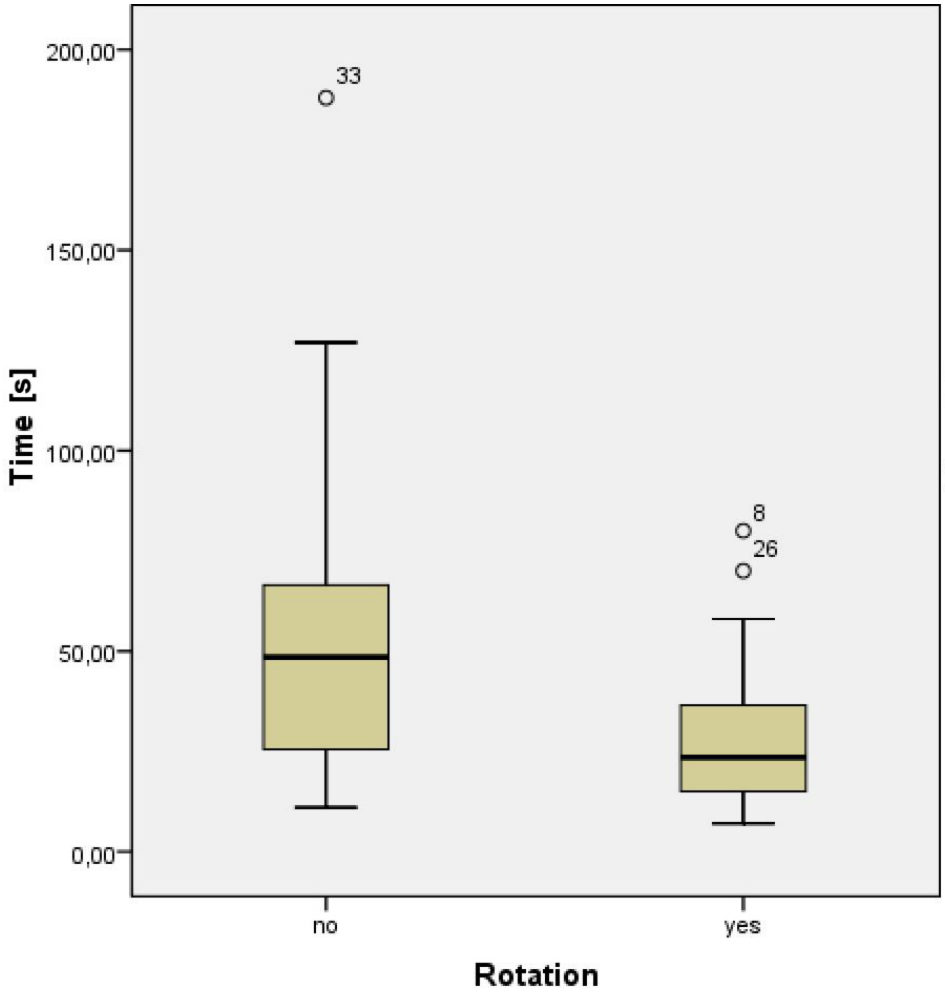
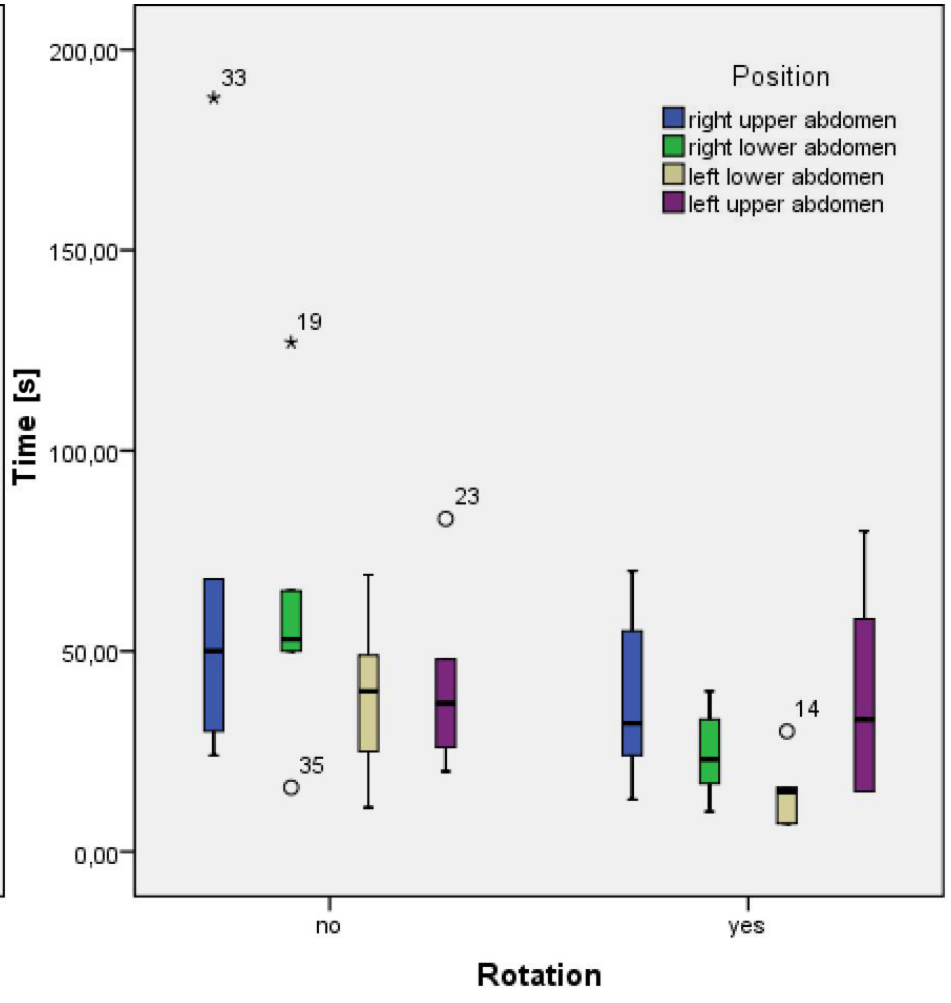


Figure: Original (l) and rectified (r) image

Clinical Evaluation

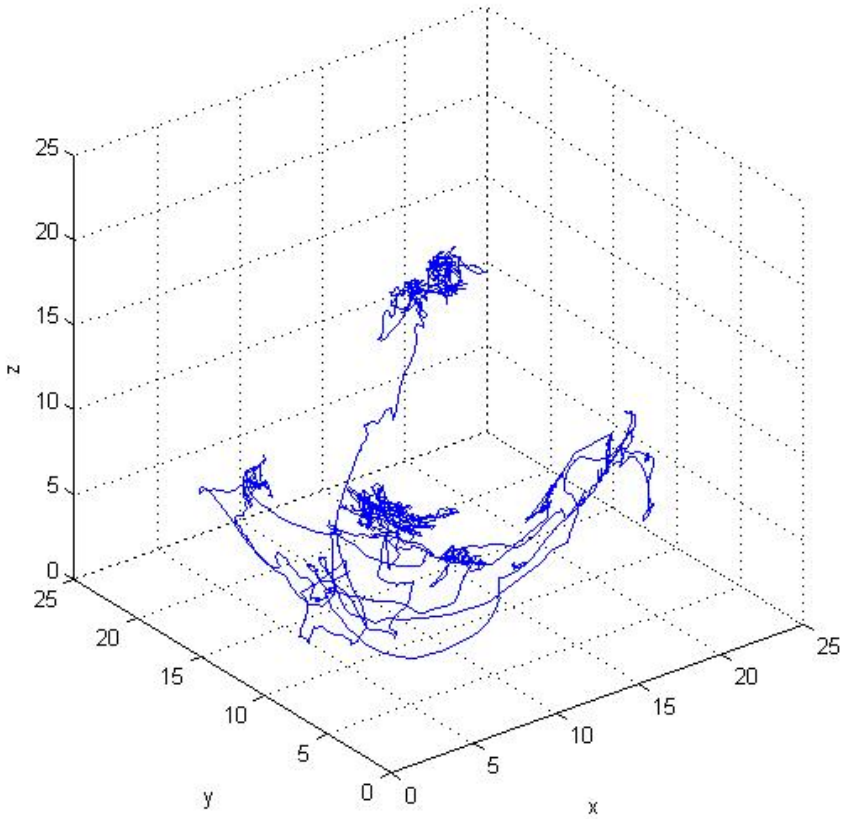
Average time comparison without and with image rectification

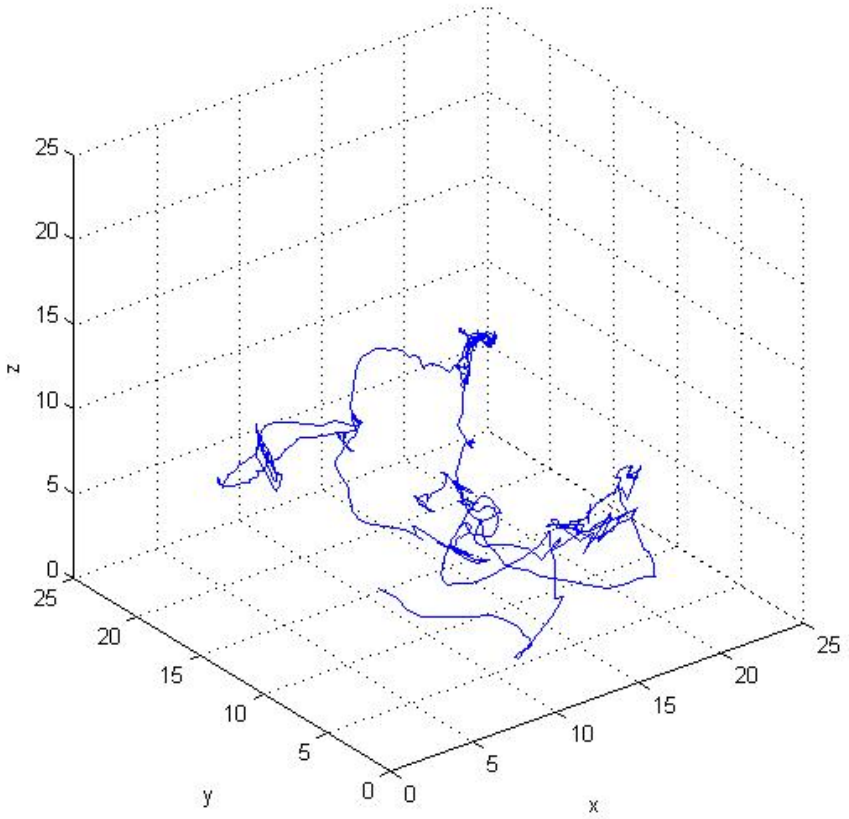




Clinical Evaluation

Original vs. rectified images: total path length of 650 vs. 317 inches





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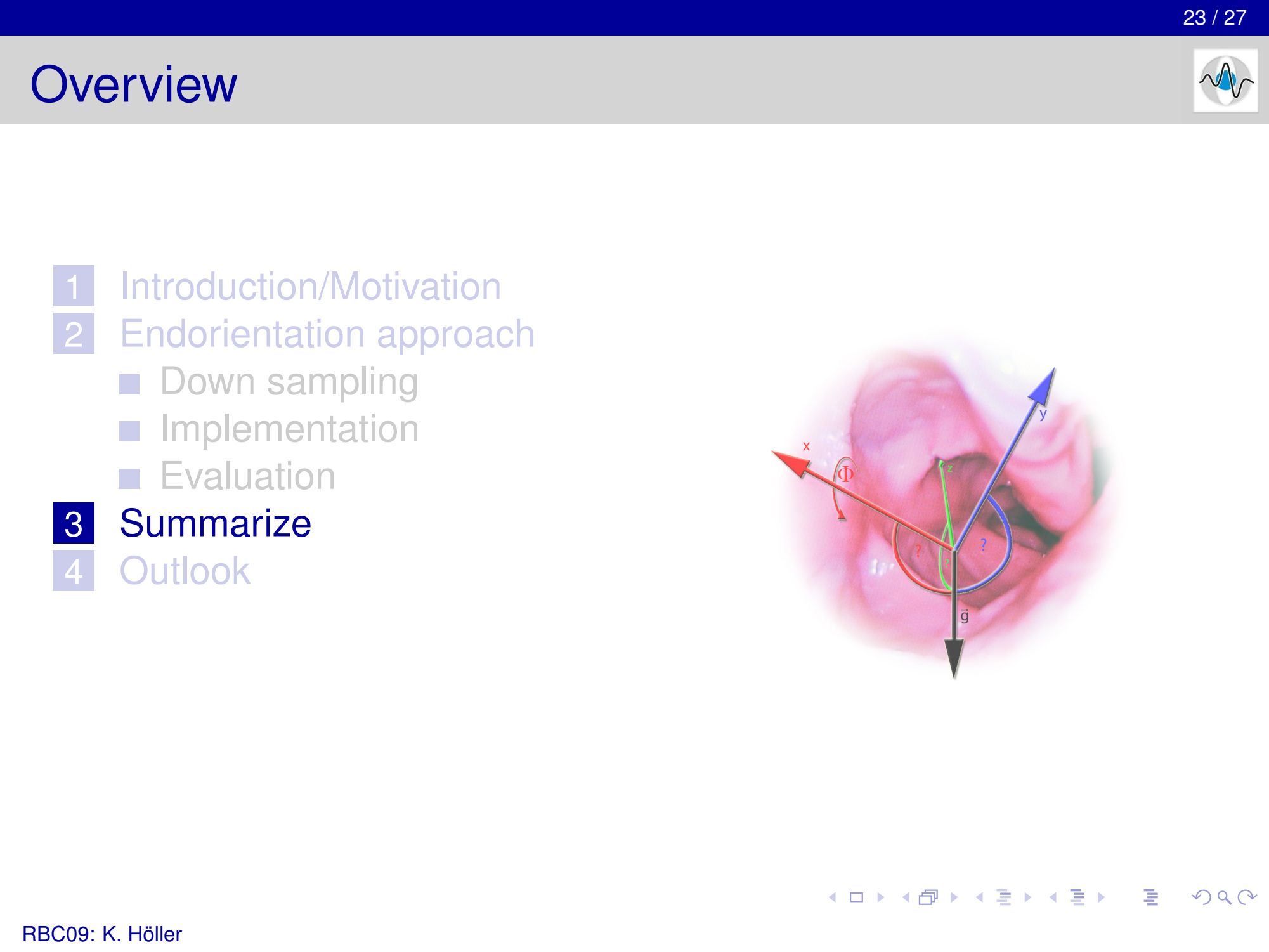
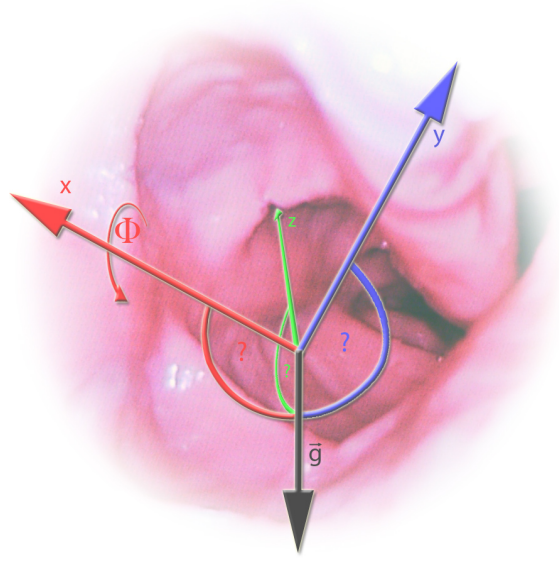


Conclusion

- Idea:
  $\Rightarrow$ fix a tiny inertial sensor on a flexible endoscope's tip
  $\Rightarrow$ rectify orientation of endoscopic view, provide a stable horizon
- Solution:
  $\Rightarrow$ tiny circuit board, I2C communication and register setting
  $\Rightarrow$ down sampling, filtering and threshholding
- Evaluation:
  $\Rightarrow$ interventions with flexible endoscopes easier esp. for surgeons

Overview



Outlook

Better technical evaluation of down sampling and filtering

- testing algorithms with synthetic data (collision / continuous tremor)
- testing in a surgery simulation area (turn table)

The End

- Thank you for your attention!
- Any further questions?