Measurement method for urine puddle depth in dairy cow houses

as input for Ammonia Emission Modelling

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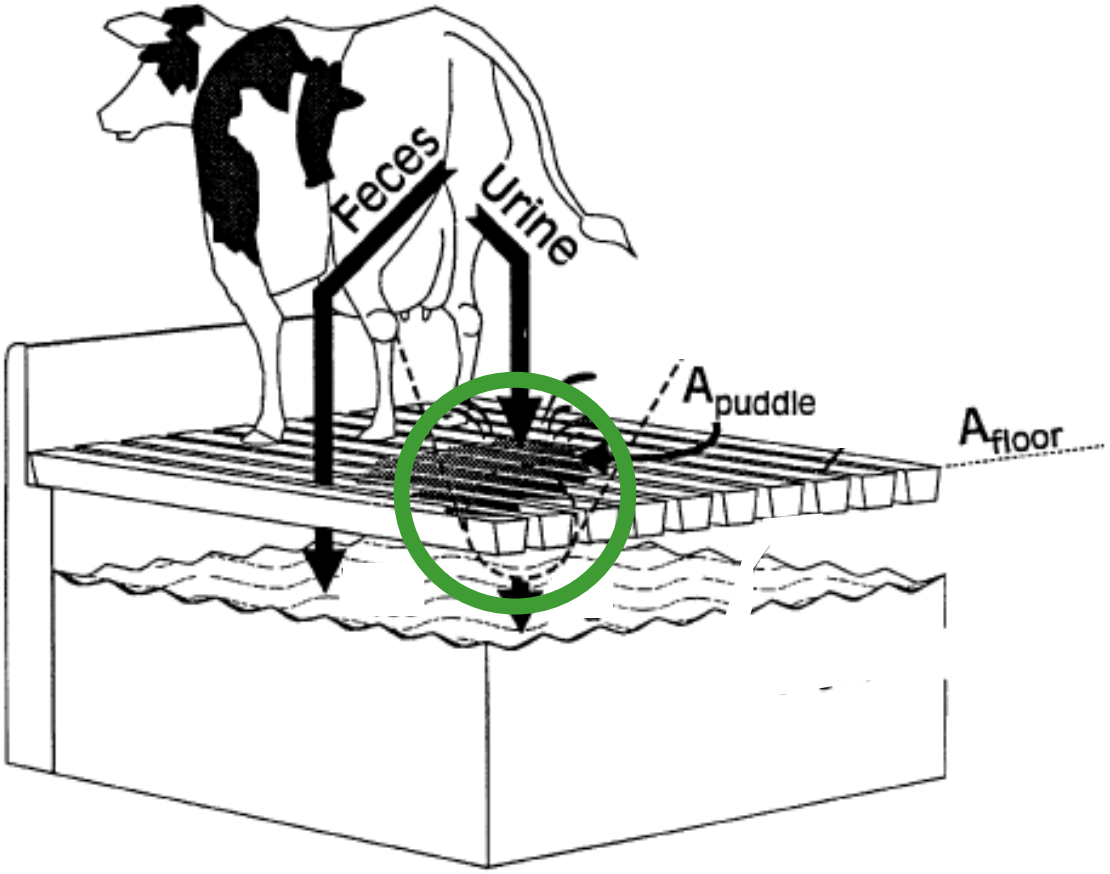
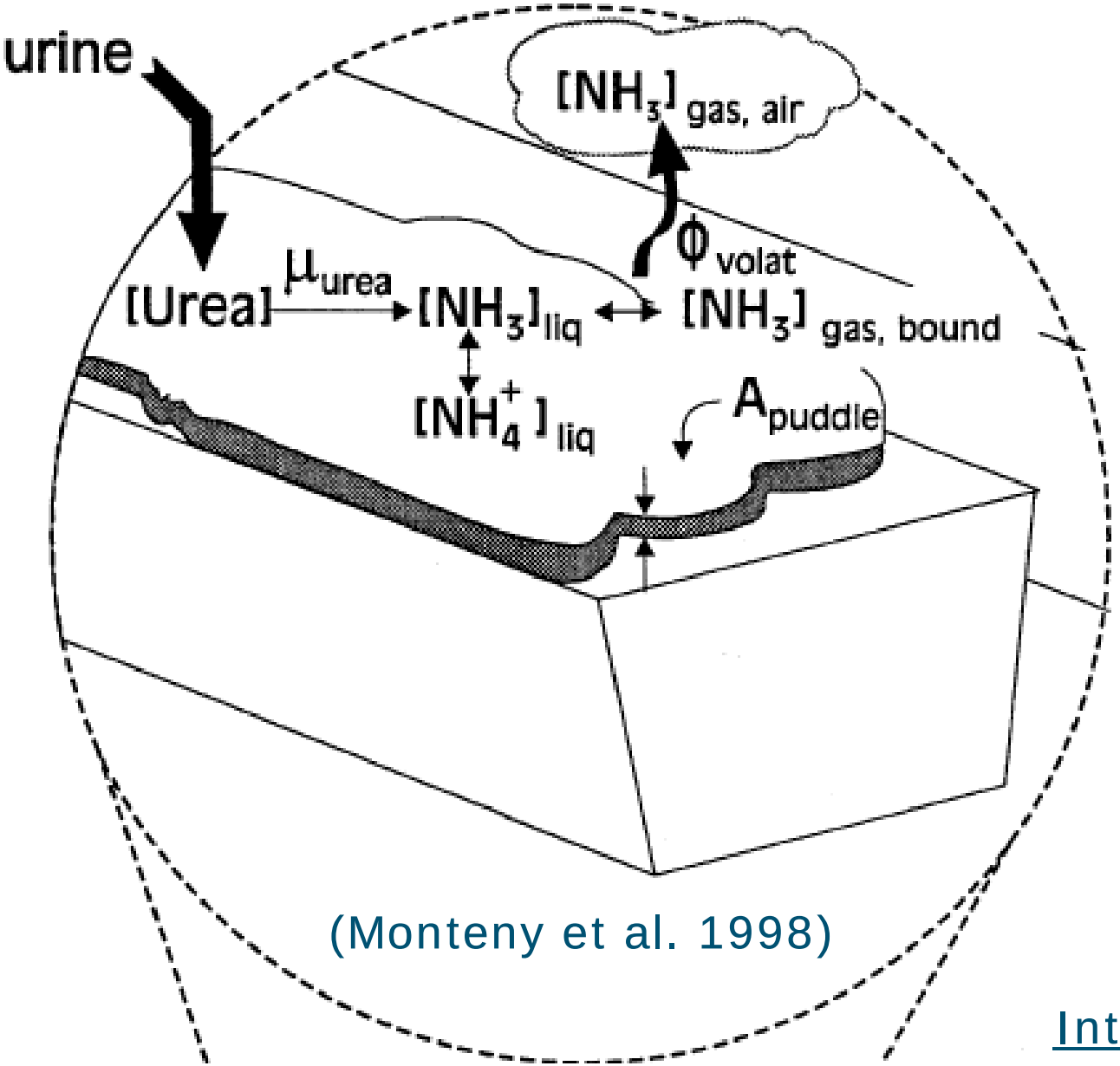
Ammonia Emission Process



(Monteny et al. 1998)

Ammonia Emission Process



(Monteny et al. 1998)

Introduction

Most sensitive input variables

1. Puddle pH
2. Puddle depth
3. Initial urea concentration
4. Puddle area
5. Puddle temperature

(Snoek et al., 2014. Sensitivity Analysis, Biosystems Engineering)

Most sensitive input variables

1. Puddle pH
2. Puddle depth **0.13 - 1.60 mm**
3. Initial urea cor
4. Puddle area **Slatted floor = 0.48 mm**
5. Puddle temperature

(Snoek et al., 2014. Sensitivity Analysis, Biosystems Engineering)

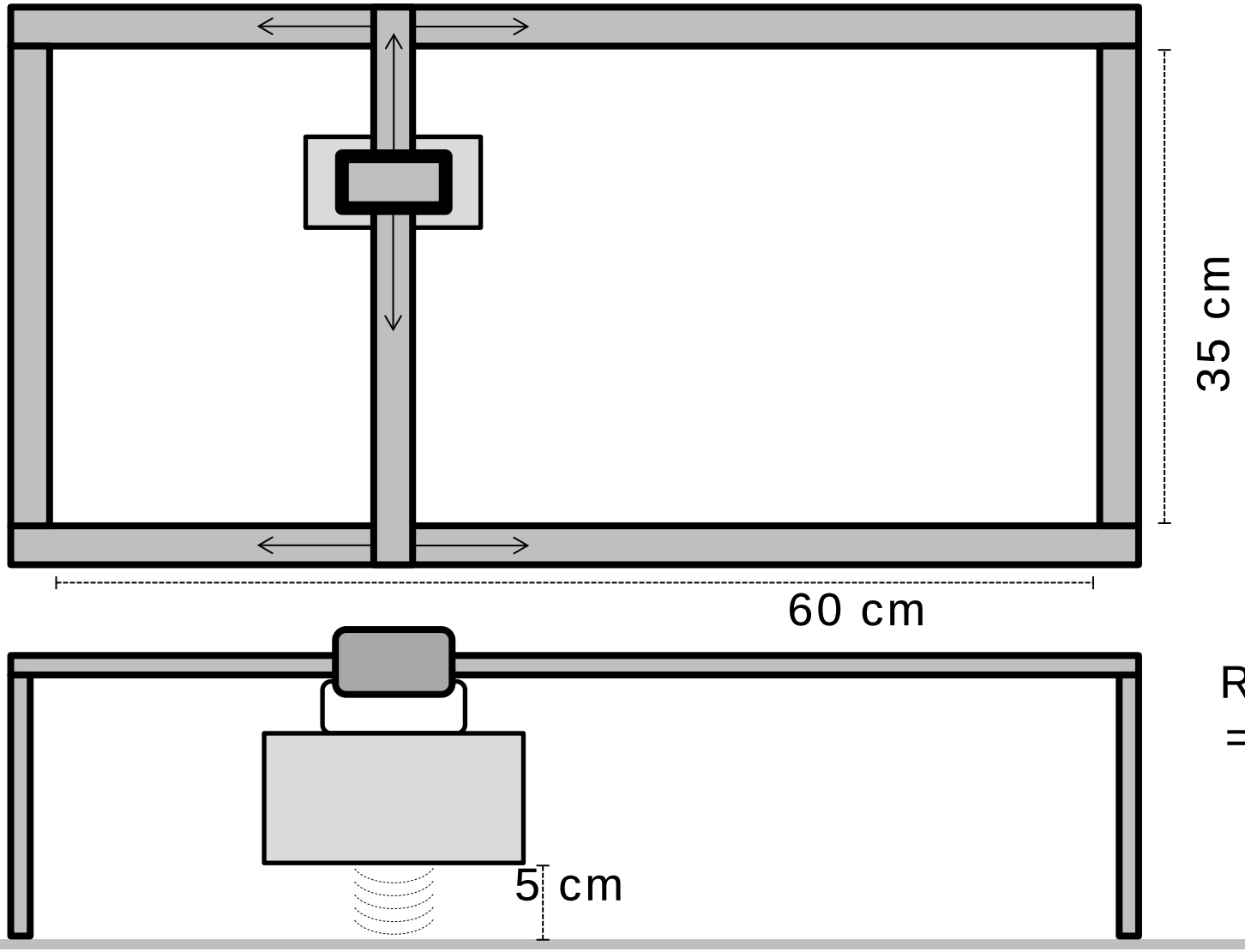
Objective

Develop a method to measure urine puddle depth on floors

Requirements

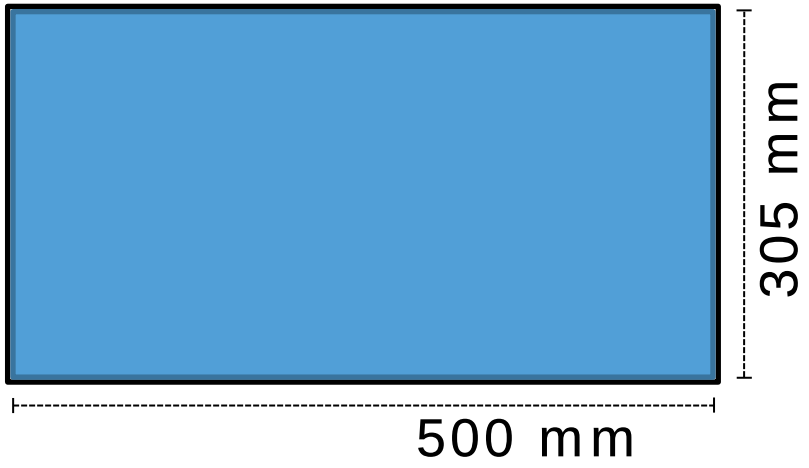
- Applicable in commercial dairy cow houses
- Measurement uncertainty ≤0.1 mm

Ultrasonic method

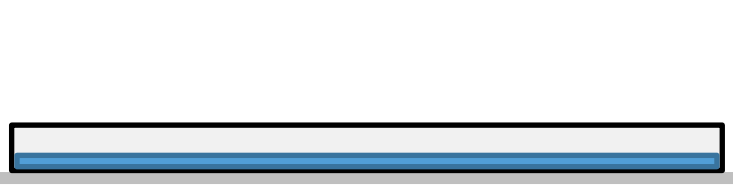


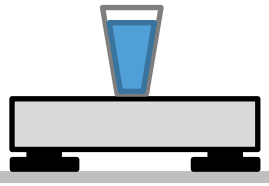
Resolution
= 0.1 mm

Balance method (golden standard)



0.1 mm =
0.015 kg

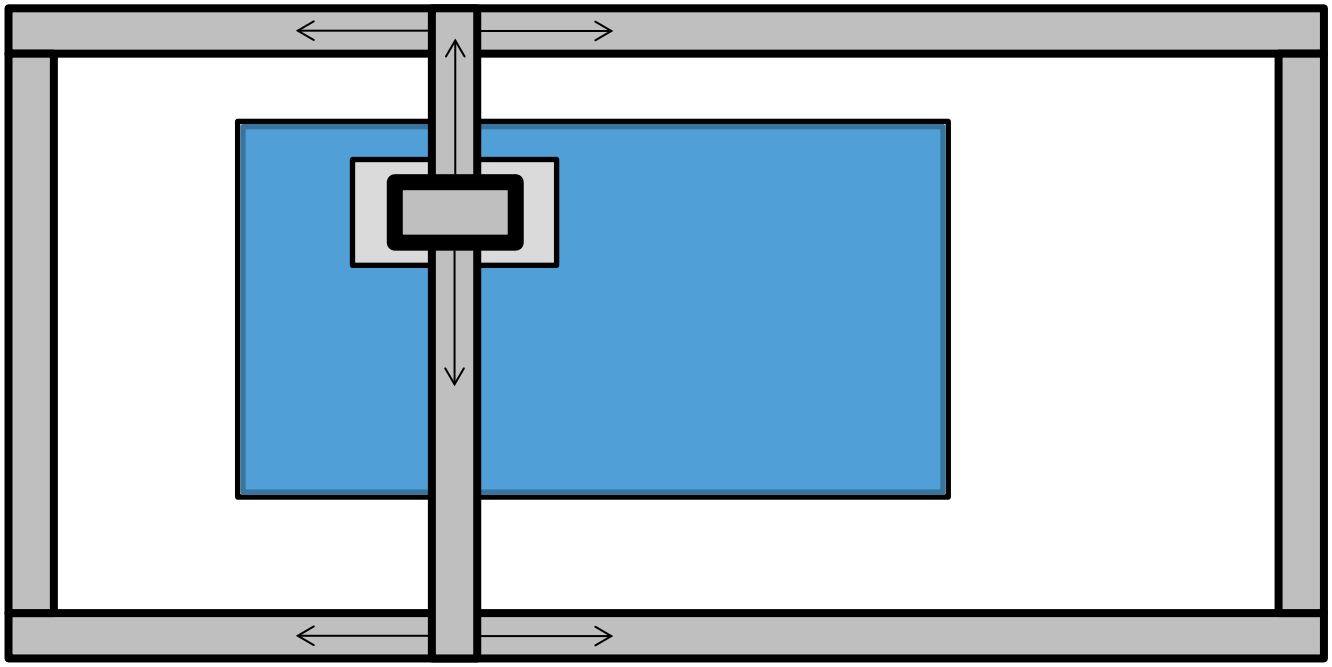


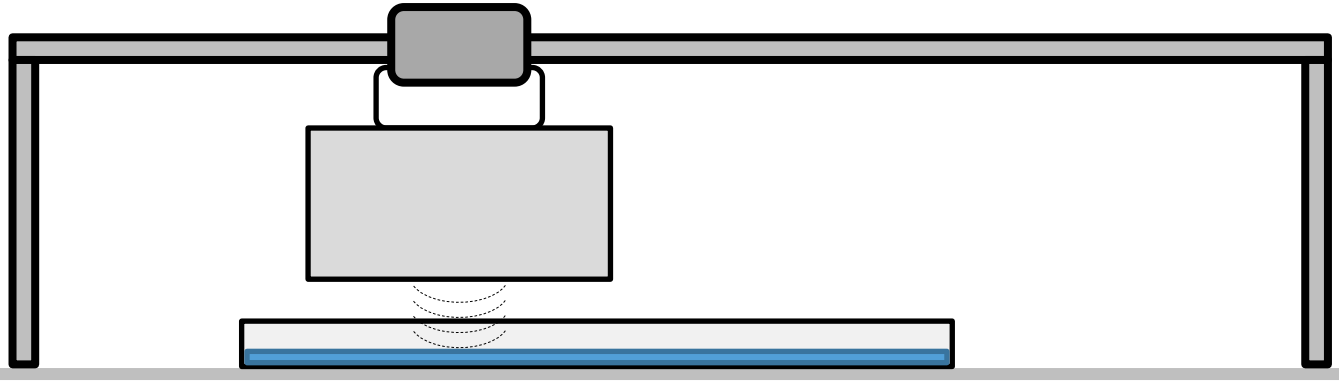


Overview experiments

1. Relation golden standard & ultrasonic method?
    - Varying depths
    - Increase and decrease of depth value
2. Influence of moving the ultrasonic?
    - The movement itself
    - In series ***vs*** random movement
3. Possibilities in practise?
    - Use of commercial available floor
    - Determine depth ‘before’ ***vs*** ‘after’ puddle presence

Experiment 1





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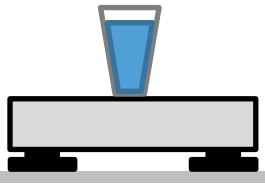
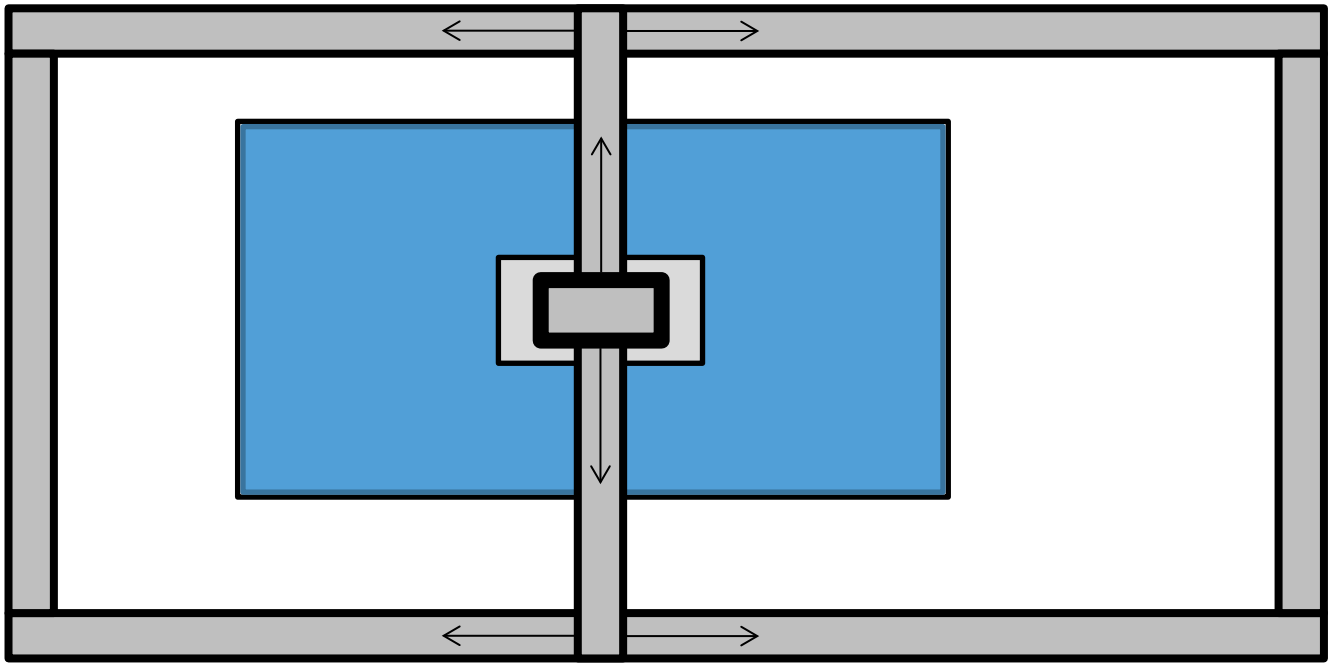
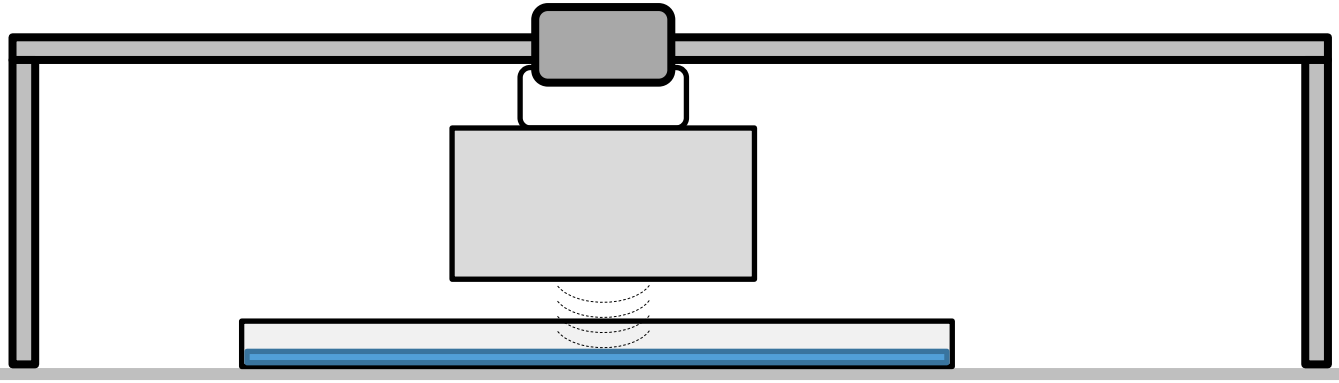


Experiment 1



N = 44



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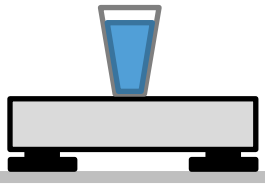

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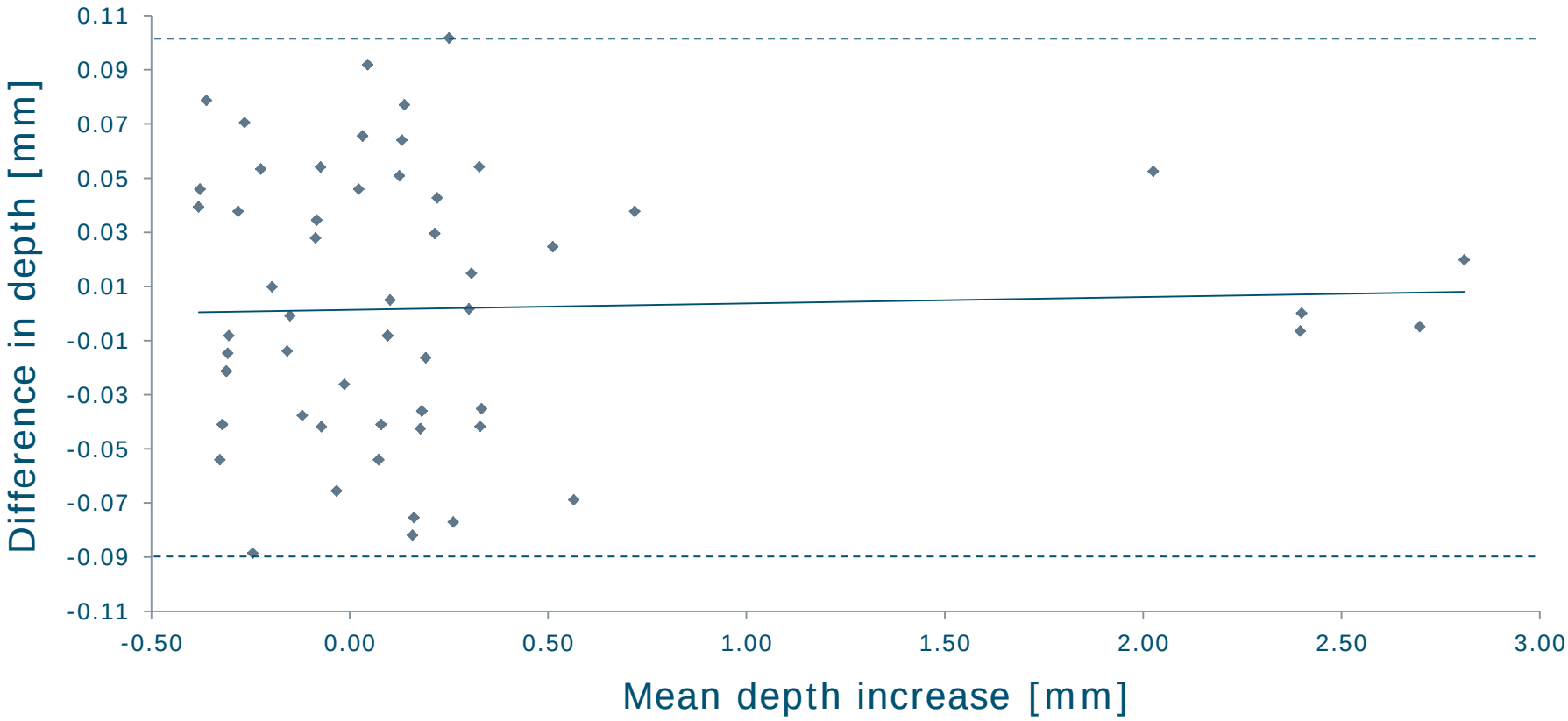

Tukey means difference plot with 95% limits of agreements

No systematic difference: $R^2 = 0.0012$ ($p=0.78$)

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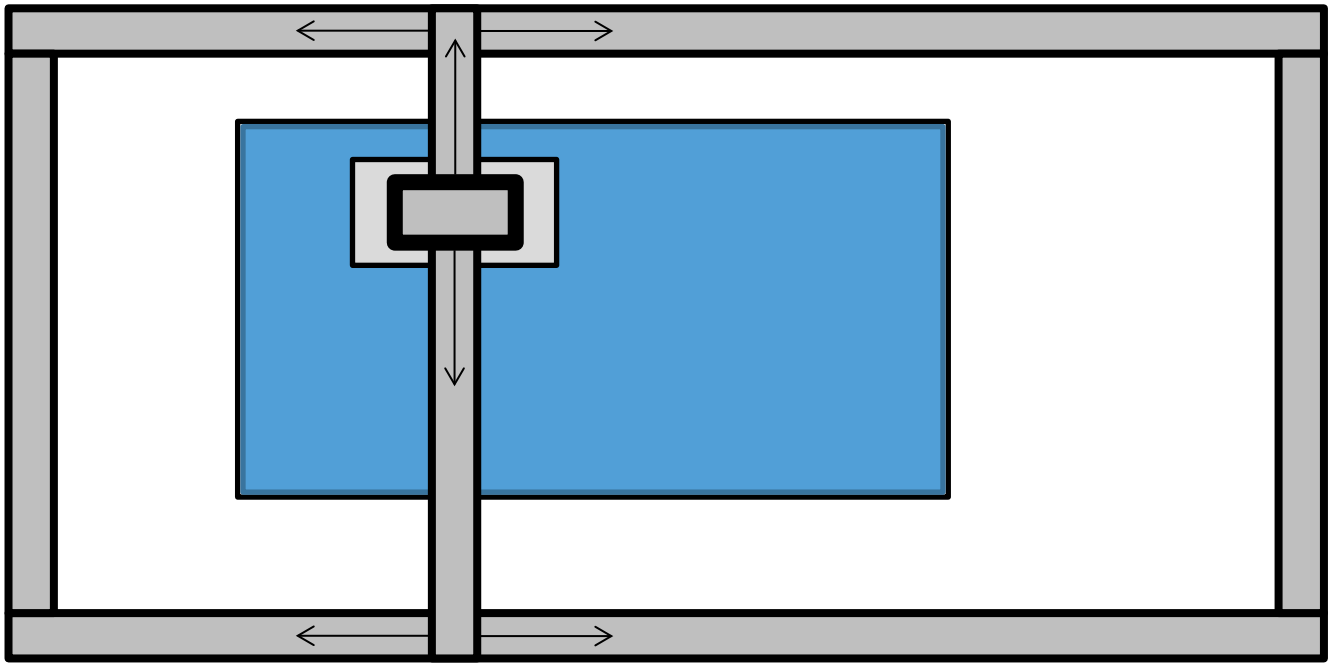
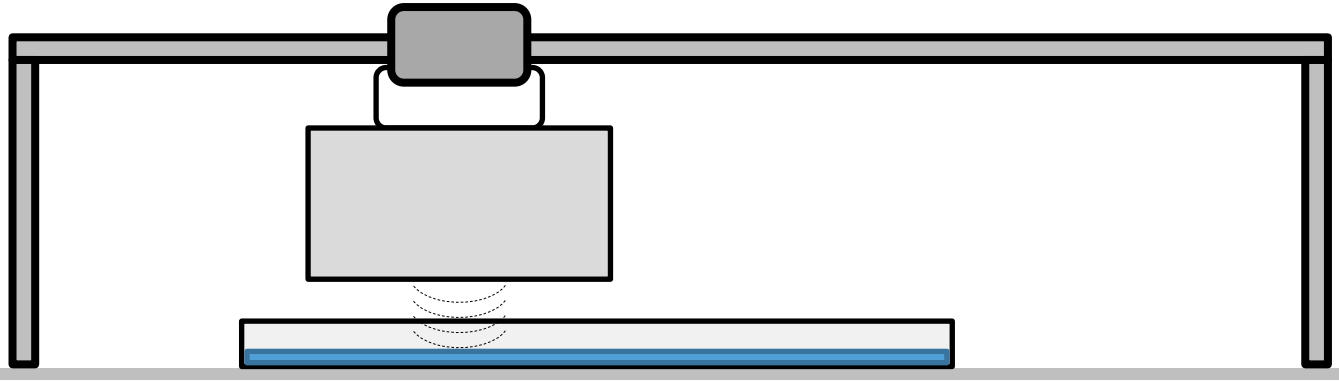
Results

Experiment 2





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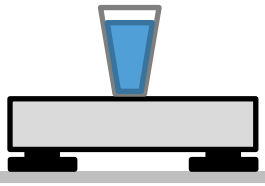
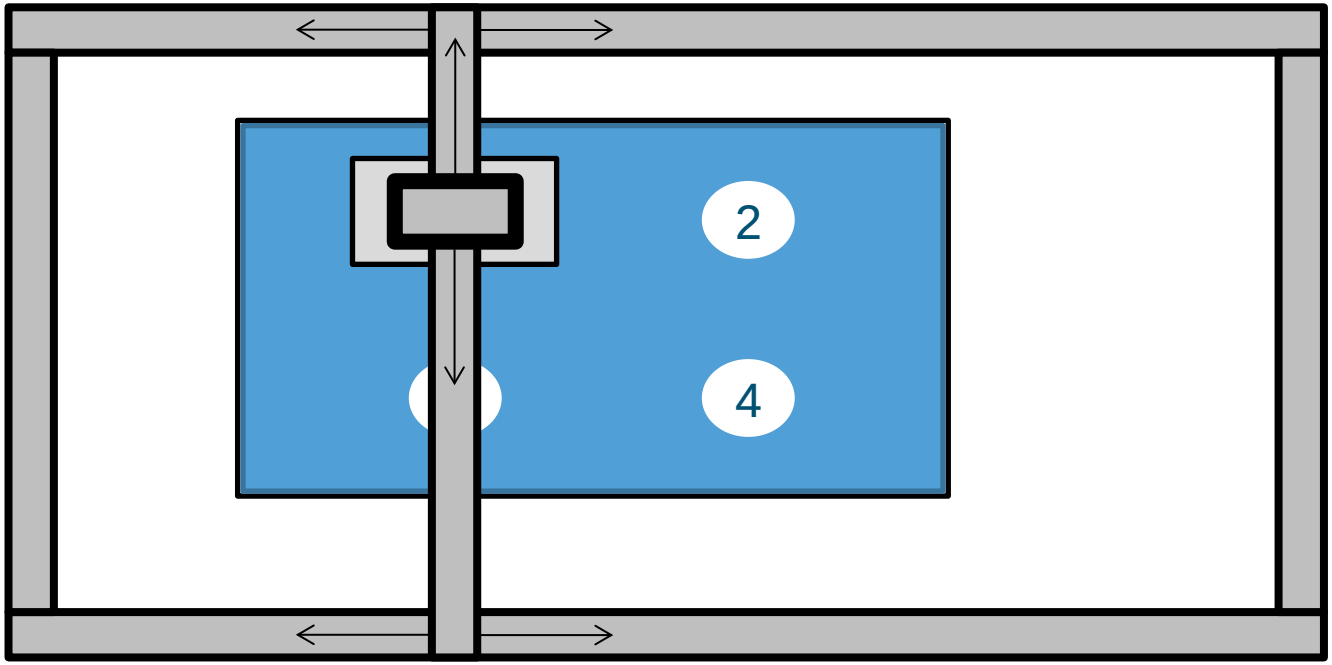


Experiment 2



- Movement => 3x in series & 3x random
- Depth = distance to bottom – distance to water layer
- 2 depth's

Experiment 2

	Depth 1		Depth 2	
Movement order	Fixed	Random	Fixed	Random
N	12	12	12	12
Mean depth, mm (SE)	0.10 (0.02)	0.10 (0.01)	0.18 (0.03)	0.18 (0.02)
Depth, mm (balance method)	0.10		0.15	
Mean difference, mm (p-value)	<0.01 (1.000)		-0.01 (0.784)	

No significant difference (>0.05) between depth of ultrasonic and depth by balance method

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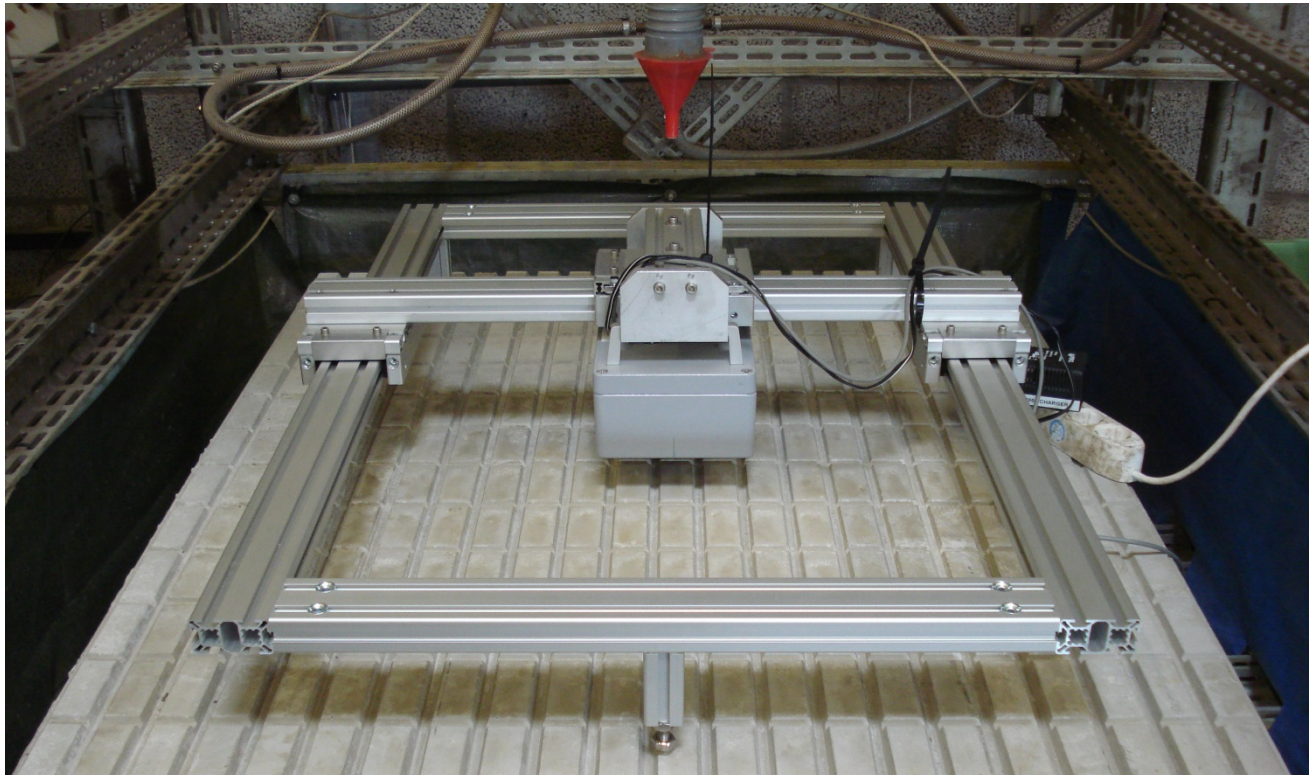
Results

Experiment 3



3	6	9
2	5	8
1	4	7

- Movement => 1x in series & 1x random
- Depth = distance to bottom – distance to puddle
- 3 puddles => 6x depth calculation

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Material & Methods

Experiment 3

	Depth 1 *(before puddle)*			Depth 2 *(after puddle)*		
Puddle	1	2	3	1	2	3
N	20	10	20	20	20	20
Mean depth, mm	0.68	0.65	0.71	0.68	0.66	0.70
(SE)	(0.05)	(0.11)	(0.04)	(0.05)	(0.08)	(0.04)
Mean depth, mm (SE)		0.68 (0.03)			0.68 (0.03)	
Mean difference in mm (p-value)			<0.01 (1.000)			

No significant differences between all puddles

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Results

Discussion

- Balance method was golden standard
  - » Lower measurement uncertainty than Ultrasonic device

- Ultrasonic device is sensitive for T, v and $d_{sensor\text{-}object}$
  - » T-sensor on device to correct for T
  - » $d_{sensor\text{-}object}$ was 5 cm
    - » No T, v and $d_{sensor\text{-}object}$ problems
    - » In preliminary experiment checked up to 8 cm

Conclusions

Ultrasonic method can measure urine puddle depth on floors

- With measurement uncertainty of 0.1 mm
- Movement had no effect
- Movement order had no effect
- Applicable on commercial available floor

Take Home

Now we can measure

the depth of their urine puddles