Comparison of different Computer-aided data acquisition systems for physics lessons

A study performed as a students thesis at TUDa

Darmstadt, Germany

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Contents

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WHY TO CONDUCT SUCH A COMPARISON?

Why to conduct such a comparison?

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- **Personal interest** because I am studying physics education
- **Find relevant criteria** that make a good data-acquisition system
- **Give teachers a tool to decide** what system they may wanna buy for their schools

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THE DATA-ACQUISITION SYSTEMS

The data-acquisition systems

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- Pasco Scientific (USA)
- PHYWE Systeme GmbH & Co. KG (Germany)
- Vernier Software & Technology (USA)

The data-acquisition systems

- **Acceleration Sensors**
- **Motion Sensors**
- **Rotary Motion Sensors**
- **Pressure Sensors**
- **Force Sensors**
- **Light Sensors**
- **Magnetic field Sensors**
- **Voltage Sensors**
- **Current Sensors**
- **Temperature Sensors**

These have all been compared in the thesis

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- **Voltage Sensors**
- **Current Sensors**
- **Temperature Sensors**

These have all been compared in the thesis

- Sound Sensors
- pH Sensors
- O_2 Sensors
- CO_2 Sensors

These have not been compared in the thesis

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HOW ARE THE SYSTEMS COMPARED?

How are the Systems compared?

- **Emphasis** on the use in school‘s physics lessons
- A set of **criteria** is needed to compare
- To get the criteria we **performed experiments** with the data-acquisition systems which can be expected in a physics lesson in school
- Every sensors data is also monitored with a different sensor using equations to relate the different physical quantities

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CONDUCTING EXPERIMENTS TO GET CRITERIA FOR COMPARISON

Conducting Experiments to get criteria for comparison

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- A total of **9 experiments performed**
- **All 10 sensors were used** in the experiments

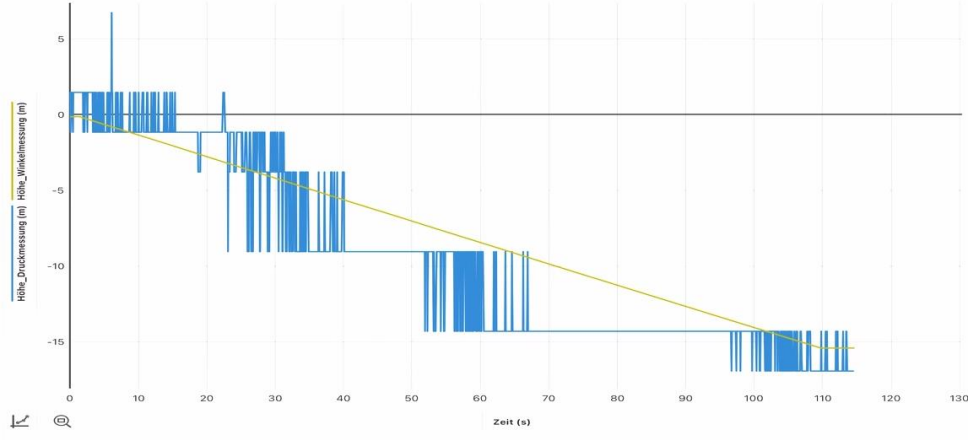
Conducting Experiments to get criteria for comparison

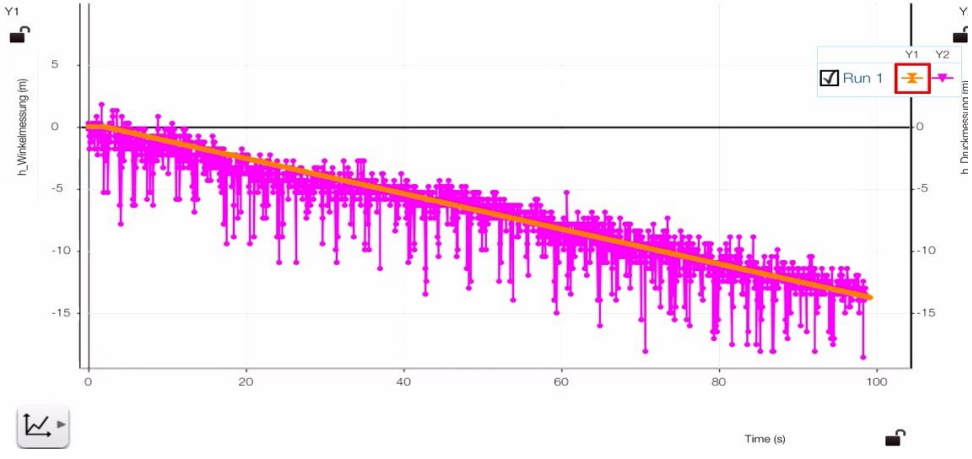
- A total of **9 experiments performed**
- **All 10 sensors were used** in the experiments

We prepared a short video for you to see one experiment, which lead to one major criteria for the comparison

Conducting Experiments to get criteria for comparison

Not all the criteria are hardware-criteria!





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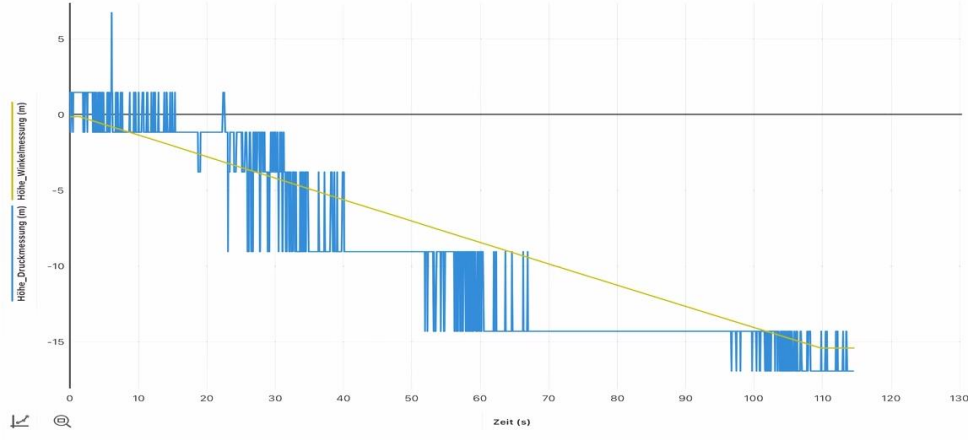

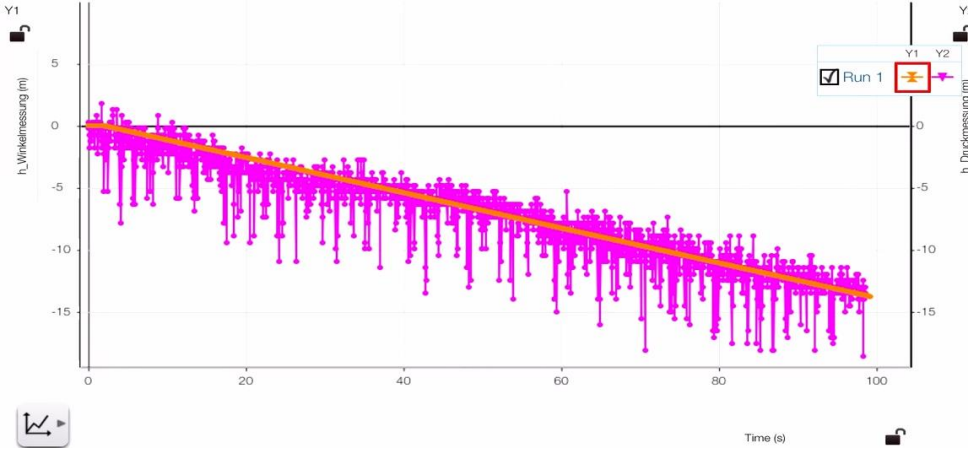

Conducting Experiments to get criteria for comparison

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Hardware-criteria:

- Handling
- Battery life
- Bluetooth range
- Resolution
- Measure range
- Sampling rate
- Datalogging

Software-criteria:

- System requirements
- Intuitiveness
- Display variety
- Calculated quantities
- Data-sharing
- Practical

… … … and Costs

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HOW TO CALCULATE THE UTILITY OF A SYSTEM FROM THE CRITERIA?

How to calculate the utility of a system from the criteria?

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- Criteria range from plain specification-like values to boolean-type true or not true values
- Criteria have different weightings (subjective)
- The goal is to get one utility-value to compare the systems

How to calculate the utility of a system from the criteria?

- Criteria range from plain specification-like values to boolean-type true or not true values
- Criteria have different weightings (subjective)
- The goal is to get one utility-value to compare the systems

- **Answer: Utility-Analysis**

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UTILITY-ANALYSIS: BRIEF SUMMARY

Utility-Analysis: Brief summary

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Criteria	Weighting	Pasco	Phywe	Vernier
Handling	5 %	10	6.17	6.88
Battery life	6 %	10	10	10
Bluetooth range	7 %	10	10	10
Resolution	7 %	**8.63**	**4**	**10**
Uncertainty	3 %	7.85	4.28	10
Measure range	10 %	10	9.68	8.81
Sampling rate	9 %	9.42	8.58	10
Datalogging	3 %	10	5	0
System requirements	7 %	10	4.62	8
Intuitiveness	10 %	3	10	7.5
Display variety	10 %	10	6.39	9.4
Calculated quantities	8 %	10	2	8
Data sharing	4 %	10	2.5	4
Practical	1 %	6.67	8.89	10
Costs	10 %	7.86	10	7.36
Utility-Value		**8.84**	**7.22**	**8.31**
Utility-Value of the Hardware		4.79	3.91	4.43
Utility-Value of the Software		3.27	2.31	3.15

Utility-Analysis: Brief summary

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- Criteria are weighted
- Weightings add up to 100%

Criteria	Weighting	Pasco	Phywe	Vernier
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Utility-Analysis: Brief summary

- Criteria are weighted
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- Criteria-values are normalized
- We used a 10-point-scale

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Bluetooth range	7 %	10	10	10
Resolution	7 %	**8.63**	**4**	**10**
Uncertainty	3 %	7.63	1.33	10
Measure range	10 %	10	9.68	8.81
Sampling rate	9 %	9.42	8.58	10
Datalogging	3 %	10	5	0
System requirements	7 %	10	4.62	8
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Utility-Analysis: Brief summary

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- Criteria are weighted
- Weightings add up to 100%
- Criteria-values are normalized
- We used a 10-point-scale
- Sum up the weighted criteria-values

- **Result is a utility-value, which will rank the systems**

Criteria	Weighting	Pasco	Phywe	Vernier
Handling	5 %	10	6.17	6.88
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Utility-Analysis: Check for Bias

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1) Equal Weightings

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Practical	6,67 %	6.67	8.89	10
Costs	6,67 %	7.86	10	7.36
Utility-Value		**8.90**	**6.81**	**8.00**
Utility-Value of the Hardware		5.06	3.85	4.38
Utility-Value of the Software		3.31	2.29	3.13

Utility-Analysis: Check for Bias

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2) Inverted Weightings

Criteria	Weighting	Pasco	Phywe	Vernier
Handling	9,23 %	10	6.17	6.88
Battery life	7,69 %	10	10	10
Bluetooth range	6,15 %	10	10	10
Resolution	6,15 %	8.63	4	10
Uncertainty	12,31 %	7.85	4.28	10
Measure range	1,54 %	10	9.68	8.81
Sampling rate	3,08 %	9.42	8.58	10
Datalogging	12,31 %	10	5	0
System requirements	6,15 %	10	4.62	8
Intuitiveness	1,54 %	3	10	7.5
Display variety	1,54 %	10	6.39	9.4
Calculated quantities	4,62 %	10	2	8
Data sharing	10,77 %	10	2.5	4
Practical	15,38 %	6.67	8.89	10
Costs	1,54 %	7.86	10	7.36
Utility-Value		**8.98**	**6.17**	**7.51**
Utility-Value of the Hardware		5.48	3.76	4.31
Utility-Value of the Software		3.38	2.27	3.09

Utility-Analysis: Check for Bias

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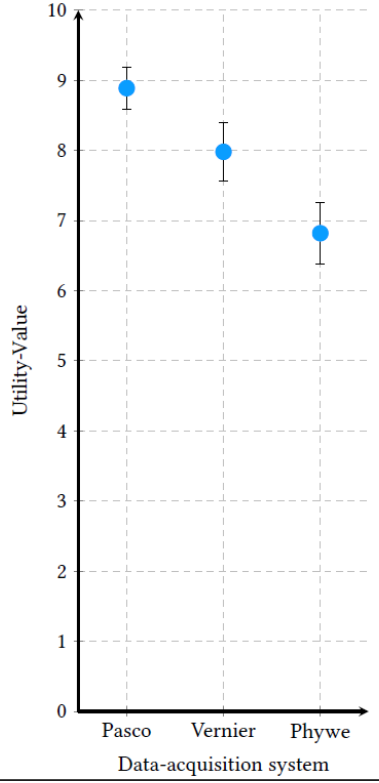
3) 1000 randomized Weightings



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CONCLUSION

Conclusion

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- We were able to identify criteria for a good data-acquisition system
- With emphasis on the use in school physics lessons we were able to rank the systems we compared
- The analysis can be adjusted for specific needs by simply adjusting the weightings
- The analysis can be adjusted for new data or changes in the systems specifications/software

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OUTLOOK

Outlook

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- The weighting should be performed with a survey (physics teachers)
- More experiments (could also be surveyed with teachers)
- Other sensors should be added to the analysis
- Other manufacturers should be added to the analysis
- Emphasis on other subjects (biology, chemistry)
- Emphasis on other institutions (university level education)

Contacts

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Thank you very much for your attention and time

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The Thesis as Download (german):

https://www.physik.tu-darmstadt.de/media/fachbereich_physik/phys_studium/vorlesungsassistenz/wiss___hausarbeiten/WH-Vergleich-computerunterstuetzter-messwerterfassungssysteme_sekyra.pdf

Questions

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There will be time for your questions now