HOCHSCHULE HANNOVER UNIVERSITY OF APPLIED SCIENCES AND ARTS

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- Industry 4.0 and Society 5.0 for Smart Society -

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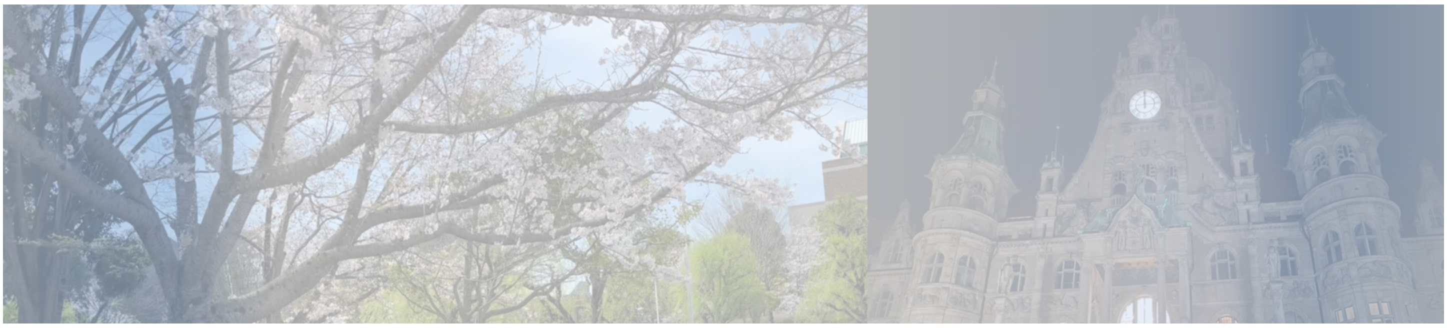

OHJG2023

Organized by: Okayama Prefectural University &

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Sponsored by Sakura Science Program of Japan Science and Technology Agency

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Sponsor: Sakura Science Program by Japan Science and Technology Agency (JST)

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Preface

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On behalf of the Organizing Committee of OPU-HsH Japan-Germany Symposium 2023 (OHJG2023), it is with great honor and pleasure that we welcome all of the participants to OPU-HsH Japan-Germany Symposium 2023, held on 15 February, 2023, at Okayama Prefectural University Campus, Okayama, Japan. We appreciate the help of the main sponsoring bodies, Sakura Science Program of Japan Science and Technology Agency (JST) as well as the co-organizing body of Okayama Prefectural University, Japan and Hochschule Hannover University Applied Science and Arts in Germany, who have made us to this symposium as a memorable and valuable event.

The first OHJG2022 was supposed to be held in OPU but shifted to virtual due to the COVID19 pandemic situation. Thanks to the continuous support from JST, Organizing Committee of OHJG2023, the second OHJG2023 will be held on site where the delegates from HsH and participants from OPU will have a face-to-face discussion on the various topics presented in this symposium under the title of Industry 4.0 and Society 5.0 for smart society.

The committee members of OHJG2023 join us in thanking every one of the presenters for their valuable contribution towards the success of this symposium, and wish all of the participants a professionally rewarding and enjoyable event.

Symposium Co-chair of OHJG2023
Okayama Prefectural University

Teruaki Ito

Prof. Teruaki Ito

Symposium Co-chair of OHJG2023
Hannover University of Applied Science and Arts

Jens Hofschulte

Prof. Jens HOFSCHULTE

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Agenda

PROGRAM

9:45- 9:55		Opening Welcome Message:
		/Prof. Teruaki ITO(Okayama Prefectural University)
		/Prof. Jens Hofschulte(Hanover University of Applied Sciences and Arts)
9:55- 10:00		Instruction for presenters:
		/Prof. Hironori TAKIMOTO (Okayama Prefectural University)
10:00-11:20		Session 1 : Chaired by Prof. Naoto HARUKI (Okayama Prefectural University)
	101	Neural network-based classification of image feature points on endoscopic surgery video
		/Masanao KOEDA (Okayama Prefectural University)
	102	Development of a monitoring system for assessing animal behavior over a fattening period
		/Gurubaran RAVEENDRAN & Johannes RADANT (Hanover University of Applied Sciences and Arts)
	103	NIRS analysis on prefrontal cortex activity during rhythm action games
		/Fumiya CHIBA (Okayama Prefectural University)
	104	Improvement of common power engineering tasks with black-box optimization
		/Lukas PETERS (Hanover University of Applied Sciences and Arts)
11:20-12:30		Lunch Break
12:30-13:00		Invited talk : Chaired by Prof. Teruaki ITO (Okayama Prefectural University)
	201	Human-entrained embodied interaction and communication technology
		/Tomio WATANABE (Okayama Prefectural University)
13:00-13:10		Photo session
13:10-14:30		Session 2 : Chaired by Prof. Akira TSUMAYA (Okayama Prefectural University)
	301	Conceptual framework for assessment of value-in-use
		/Yusuke TSUTSUI (Okayama Prefectural University)
	302	Predictive maintenance for washing machines
		/Constantin MUND (Hanover University of Applied Sciences and Arts)
	303	Development of an Embodied Avatar-Agent Dialogue System to Support Communication Education for Clinical Engineer Students
		/Shingo KATAOKA (Okayama Prefectural University)
	304	Opportunities for using digital pens to improve higher education teaching
		/Patrick DETMER (Hanover University of Applied Sciences and Arts)
14:30-14:40		Short Break
14:40-16:00		Session 3 : Chaired by Prof. Katsumi SAKAKIBARA (Okayama Prefectural University)
	401	Frequency analysis of Wi-Fi received signal strength using Lomb-Scargle periodogram
		/Koichiro SAKAGUCHI (Okayama Prefectural University)
	402	Simulation of the electronic part of Mößbauer spectroscopy
		/Mohammad BEYKI (Hanover University of Applied Sciences and Arts)
	403	First-principles calculations and their application to the field of semiconductor materials
		/Akira SADA (Okayama Prefectural University)
	404	Simulation-based process optimization in the rubber industry - An exemplary use-case from a tire manufacturer
		/Marvin Martin AUF DER LANDWEHR & Christina SAND (Hanover University of Applied Sciences and Arts)
16:00-16:10		Closing message:
		/Prof. Teruaki ITO (Okayama Prefectural University) & Prof. Jens Hofschulte (Hanover University of Applied Sciences and Arts)

For online participation, please register here https://forms.gle/DEkjK2vFzjpp3tE77

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Neural Network-Based Classification of Image Feature Points on Endoscopic Surgery Video

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Keywords: Neural Network, Classification, Image Feature Point, Endoscopic Surgery Video, SLAM

The augmented reality (AR) surgical support system we are currently developing [1] estimates the position and posture of an endoscopic camera using feature point-based Simultaneous Localization and Mapping (SLAM) [2], and superimposes 3DCG models of organs and other objects on the camera image. However, feature points (thereafter, fps) appearing on surgical instruments moving in front of the camera may become noise and cause errors in the camera position and posture estimation. In this paper, we examine the feasibility of removing the fps appeared on the surgical instruments by using a neural network (NN) to discriminate the fps of the living body and those of the surgical instruments. The teacher data indicating the surgical instruments were manually generated. The ORB fps were extracted at each frame of the stereo endoscope video (FullHD, 681 frames). The created models are shown in Table 1. The total number of data is 33799.

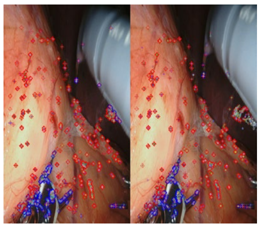

Fig. 1 One example of NN-Based classification of Image fps (◇: true value, +: classified result, red: tissue, blue: tools)

In Model A, the fp coordinates $\boldsymbol{p}_t^L, \boldsymbol{p}_{t+1}^L$ in the left camera image at time $t, t+1$, the pixel values $C_t^{L\_RGB}, C_{t+1}^{L\_RGB}$ at $\boldsymbol{p}_t^L, \boldsymbol{p}_{t+1}^L$ in the RGB color space and the fp velocity $L_t = |\boldsymbol{p}_t^L - \boldsymbol{p}_{t+1}^L|$ were used for learning. In Model B, the fp coordinates $\boldsymbol{p}_t^L, \boldsymbol{p}_{t+1}^L, L_t$ and the pixel value $C_t^{L\_HSV}$ at $\boldsymbol{p}_t^L$ in the HSV color space were used for learning. In Model C, the fp coordinates $\boldsymbol{p}_t^L, \boldsymbol{p}_t^R$ in the left and right camera images at time t, pixel values $C_t^{LRGB}, C_t^{R\_RGB}$ at $\boldsymbol{p}_t^L, \boldsymbol{p}_t^R$ in the RGB color space, and disparity $L_d = |\boldsymbol{p}_t^L - \boldsymbol{p}_t^R|$ between $\boldsymbol{p}_t^L$ and $\boldsymbol{p}_t^R$ were used for learning. In Model D, fp coordinates $\boldsymbol{p}_t^L, \boldsymbol{p}_t^R$, and pixel values $C_t^{L\_HSV}, C_t^{R\_HSV}$ at $\boldsymbol{p}_t^L, \boldsymbol{p}_t^R$ in the HSV color space, and disparity L_d were used for learning. We randomly selected 70% of the extracted fps for training and the remained for validation. Figure 1 and Table 1 show the results of classification using the created models. The correct response rate and semi-correct response rate are defined as follows.

- Correct response rate = (number of correct answers of tissue fps + number of correct answers of tools fps) / total number of fps
- Semi-correct response rate = (number of true value fps on the tissue + number of correct answers of tools fps) / total number of fps

The results showed that Models A and B had higher percentages than Models C and D. The difference between the correct response rate and the semi-correct response rate was also smaller for Models C and D (2.4% and 3.4%) than for Models A and B (5.4% and 9.2%).

Table. 1 Model name and input data set, and rate of correct responses

Model	Feature vectors	Average rate of correct response	Average rate of semi-correct response
A	$\boldsymbol{p}_t^L, \boldsymbol{p}_{t+1}^L, C_t^{L\_RGB}, C_{t+1}^{L\_RGB}, L_t$	89.3%	94.7%
B	$\boldsymbol{p}_t^L, \boldsymbol{p}_{t+1}^L, C_t^{L\_HSV}, C_{t+1}^{L\_HSV}, L_t$	85.8%	94.5%
C	$\boldsymbol{p}_t^L, \boldsymbol{p}_t^R, C_t^{L\_RGB}, C_t^{R\_RGB}, L_d$	70.4%	72.8%
D	$\boldsymbol{p}_t^L, \boldsymbol{p}_t^R, C_t^{L\_HSV}, C_t^{R\_HSV}, L_d$	68.1%	71.5%

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Optimization of light management in the husbandry of fattening turkeys

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Keywords: Animal Welfare, Turkey Husbandry, Ultraviolet Light, Artificial Intelligence, Animal Tracking

Motivation for the research project

Farmers are constantly up to optimize keeping of animals during fatting in order to maintain animal welfare but also in regards to economic standpoints. Injurious pecking is still a big challenge in fattening turkey husbandry, the economic losses suffered by the farmers are up to 10 percent. Barn automation offers numerous possibilities for optimally operating these processes with minimum amount of work and resources. However, undesirable behavior, such as injurious pecking, can only be prevented by intensive observation by the farmer, technical devices cannot yet replace humans.

This animal behavior is influenced by several factors, although ranking fights are not an abnormal behavior even between wild turkeys (Bartels et al., 2020). Unlike under intensive husbandry conditions, where individual animals can suffer severe injuries from conspecifics, rank disputes between wild turkeys are usually harmless and without permanent damage (Bartels et al., 2020).

The lighting environment can also influence behavior and stress level of turkeys. Conventional fluorescent tubes are more and more replaced by innovative light emitting diodes (LED). The influence of those LED´s, especially the role of flicker frequencies on the animal is not investigated yet, whereas it is commonly known, that the visual resolution of birds eyes is much higher than of human ones. The Lower Saxony recommendations for turkey husbandry advises light with a frequency of more than 160 Hz. But what is this frequency basing on and is it adequate for fattening turkeys as well? The spectrum of artificial light in fattening turkey husbandry must also be adapted to its species-specific perceptivity, which results in the fact, that the provided light must contain ultraviolet wavelengths. But which percentage and which composition of UV-light is adequate?

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State of art and science

Current agricultural practice uses conventional technology for the lighting of barn. They are more oriented towards compliance with legally prescribed basic conditions than the requirements for animal husbandry which is as appropriate as possible for the species. In this context, lighting is considered to be a key factor that can be used to influence behavioral abnormalities in fattening turkeys such as injurious pecking ("cannibalism"), in order to improve the welfare of the animals and profitability through reduced losses. Birds have evolved the most efficient visual organs among vertebrates. The color sensitivity of the eyes, for example, as well as the resolving power of many diurnal birds in particular, exceeds by far the performance of the human eye. In addition to color receptors, UV-sensitive sensory cells are also found in the retina of the turkey eye. Since parts of the eye upstream of the retina are also UV-permeable, it can be assumed that turkeys are able to perceive ultraviolet light. UVA-fluorescent and UVA-reflective characteristics of the plumage of fattening turkeys were described in Bartels et al. (2017). However, knowledge about the effects of artificial lighting, especially light spectrum and flicker frequency, on behavior, performance and health of fattening turkeys is limited so far (Lewis and Morris, 2006). Whether there is also potential in a turkey-specific adapted light management to minimize the incidence of undesirable behaviors will be examined in the research project.

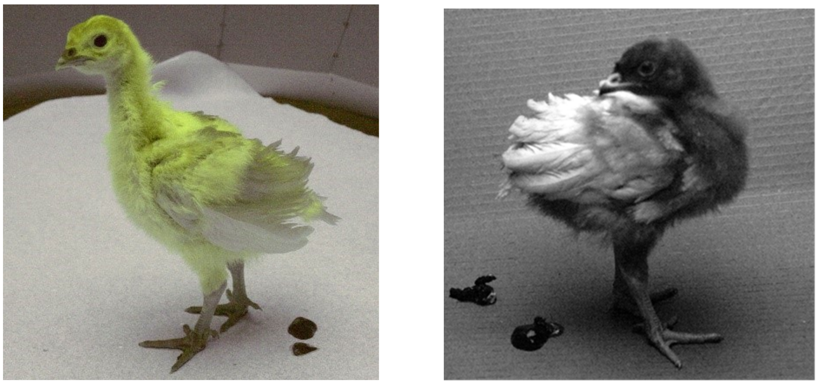

Figure 1: Images of turkey poults photographed under UVA radiation illumination (λ = 344 nm – 407 nm). Left: UV-fluorescence photography. Note the intense yellowish-green fluorescence of the natal downs. Right: UV reflectography. Growing primaries and secondaries show an intense UV reflection. [Bartels et al., 2017]

Aim

In the context of the interdisciplinary research project "Optimization of light management in husbandry of fattening turkeys", is to be developed an innovative LED-based lighting system for the keeping of fattening turkeys according to their habitat.

Based on the scientific research, it is to define the spectra of a natural lighting system that serves animal welfare and to produce a spectrally controllable lighting system using LED lighting. Under different lighting scenarios and flicker frequencies, the behavior of fattening turkeys is scientifically analyzed using behavioral observations. An AI-based object recognition system is used to continuously record turkey motion profiles under different lighting conditions. The aim is to detect damage pecking automatically, as well as other undesirable behaviors of the animals in order to improve animal welfare in fattening turkey husbandry by using animal-friendly dynamic lighting control.

Material and methods

The experimental plan foresees the use of a new lighting-system on two farms, a practical farm ("fattening barn") for applied research and an "experimental barn" of the FLI-ITT, to better assess the consequences and to prevent any major complications on the practical farm.

In the first trial, an innovative LED system was examined in a conventional practice farm (20 m x 120 m) with around 7000 turkeys ("practice flock") and individual animals were tracked within the flock via twelve high-resolution cameras. In total, 36 luminaires are installed in the barn. Each light can be controlled individually. The wanted spectrum can be determined via the three-color channels.

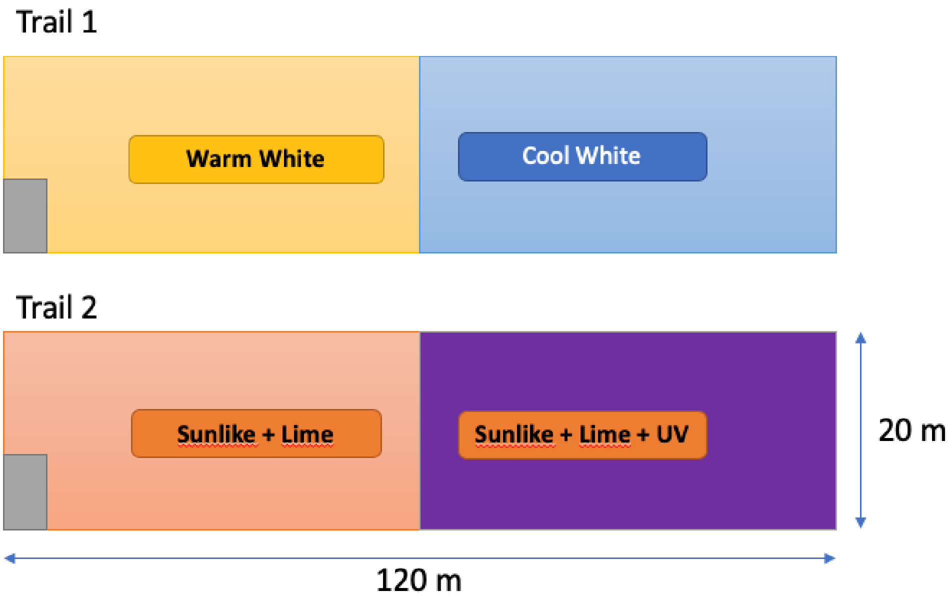

Figure 2:Lighting zone for the farm for the experiments

Due to the per channel control, the intensity can also be varied. This has the advantage that quiet areas and active areas can be illuminated individually adapted.

In the first experiment, the acceptance of cold white (5000 K) and warm white (2700 K) illuminated surfaces was tested in turkeys. Attention was focused on the activity and residence of turkeys in the respective illuminated areas. The second test will add a UVA component to the luminaire, the comparison to an illuminated area without UVA component is to be analyzed.

The "experimental flock" at the Friedrich-Loeffler Institute for Animal Welfare and Animal Husbandry Germany (FLI-ITT) is involved to assess the consequences of three different flicker frequencies (165 Hz, 500 Hz, 16 kHz) on the behavior and performance of fattening turkeys.

In the FLI-ITT experimental barn, a total of twelve compartments (each 18 m²) was used to asses flicker frequencies in three trials. Each compartment was equipped with two LED.based lamps, two drinkers, two feeders and one high-resolution camera (AXIS). Three different flicker frequencies were tested: 165 Hz /500 Hz /16.000 Hz. Per compartment, each frequency was tested per trial. Live weight of turkeys was assessed on day 1 as well as in the 7th and 21st week of life, shortly before slaughter. In week 16, the primaries ("flight feathers") Nr. III were clipped in five birds of each compartment in order to analyze feather corticosterone, which can be consulted as a long-term indicator of stress (Bortolotti et al., 2008).

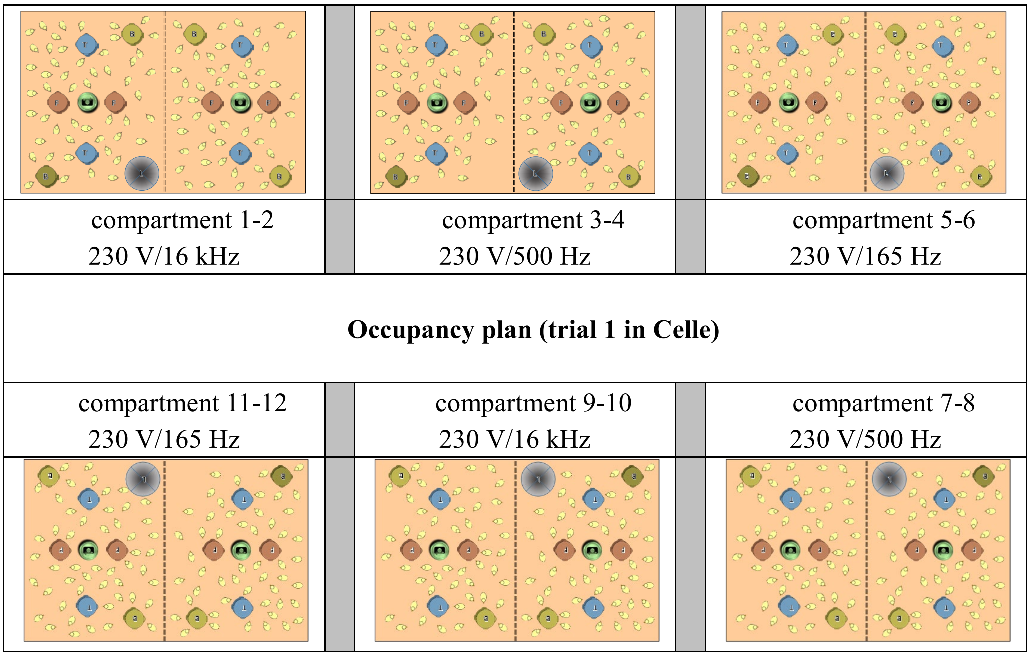

Figure 3: Experimental plan for FLI with individual compartments

Due to the automatic monitoring system, a 24/7 observation of the birds is possible. This allows the assessment of light preferences of the birds identified by the actual position or activities of the animals. Thus, light preferences of the turkeys can be assessed by means of the location or activity. This analysis is the basis for designing animal-friendly lighting in turkey farms.

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NIRS analysis on prefrontal cortex activity during rhythm action games

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Keywords: rhythm action game, NIRS-SPM, prefrontal cortex, attention, proficiency

1. Introduction

In recent years, video games have become popular as *e-sports* and many of them are available over the Internet. *e-sports* has undergone a remarkable evolution according to the development of the competitive nature of the games.

Top *e-sports* players show high level of performance, which requires superior cognition as well as human motor skills. This study focused on the clarification of cognition and motor skills of players, and measured brain activity during video game. Although the prefrontal cortex is thought to be involved in various cognitive functions in humans, activity of prefrontal cortex in video game playing is not clear. This study investigates the activity of the prefrontal cortex during game using NIRS equipment in order to clarifying differences in brain activity due to differences in game skill. Furthermore, the brain image mapping will be performed using NIRS-SPM [1]to indicate the areas of activity based on the measured changes in oxygenated hemoglobin in order to clarify the difference of brain activity due to difference in game skill.

2. Experiments

Six right-handed male adults and two left-handed male adults, aged 21-42 years, participated in the experiment after receiving a verbal explanation of the purpose of the experiment. Changes in oxyhemoglobin HbO in each channel were measured at a sampling frequency of 12.21Hz.

A rhythm action game was assigned as the task to the subjects. The experiment was divided into three sections, which are 1-button task, 9-button task, and difficult task. The difficult task was assigned based on difficulty level of the game itself as well as considering the skill level of the subjects. The experimental procedure was conducted in the following order: rest (approximately 1 minute), 1-button task, rest (approximately 1 minute), 9-button task, rest (approximately 1 minute), and difficult task. In-game scores for three sets of 9-button trials and three sets of difficult trials were recorded. In order to reduce the influence of the order in which the trials were preformed, the second set was performed in the following order: rest (approximately 1 minute), 1-button task, rest (approximately 1 minute), difficult task, rest (approximately 1 minute), and 9-button task.

3. Analysis

Peter et al. states that when neural activity occurs, arterial blood flows to the active areas of the brain to compensate for metabolic activity, resulting relative increase in Oxy-Hb concentrations and decrease in Deoxy-Hb concentrations [2].

Tony's study on bimanual coordination in the supplementary motor area of the brain using NIRS showed that there were homogeneous and reciprocal Oxy-Hb and Deoxy-Hb responses in each motor pattern, with the Oxy response having a larger amplitude and no significant difference in the Deoxy response due to inter-subject variability [3].

Based on the related researches mentioned above, this study focused on the change in Oxy-Hb concentration in both measurement data to infer prefrontal brain activity.

Prior to the analysis of the game-playing task, raw cerebral blood flow data were saved as a csv file for each channel by the measurement software, and the csv files were analyzed in MATLAB using NIRS-SPM in conjunction with SPM8.

The time series data of each channel was subjected to low-pass filtering, trend rejection by DCT, which is a function of SPM, and high-pass filtering with a cutoff of 128 sec using Time-Series-Analysis function in NIRS-SPM. Baseline processing was then performed using Initial-Time-Calculation method in NIRS-SPM. Then, this file was input to the Specify-1st-level function of NIRS-SPM to classify the time series during the task and rest periods, and generalized linear model analysis was performed by Estimate function of NIRS-SPM. The measurement data from each task was processed in this way, and a t-test was performed using the mean value of the task for each of the three trials. Brain image and its coordinate data from each channel were mapped by density change with color from white to black. The images were mapped from the brain images and each channel coordinate data using a black-white to black-colored density change.

4. Results

Turkel[4] identified different types of attention, such as stimulus-driven and controlled attention, but focuses chiefly on "working memory," our capacity to keep information in mind for short periods of time. He asserts that working memory capacity - long thought to be static and hardwired in the brain - can be improved by training, and that the increasing demands on working memory may actually have a constructive effect. The experienced subject regarded as advanced player as shown in Figure 1 supports this idea. Even more complex and continuous patterns such as difficult tasks may show significant activation in the lateral prefrontal cortex, especially related to the working memory, by selecting and judging appropriate information.

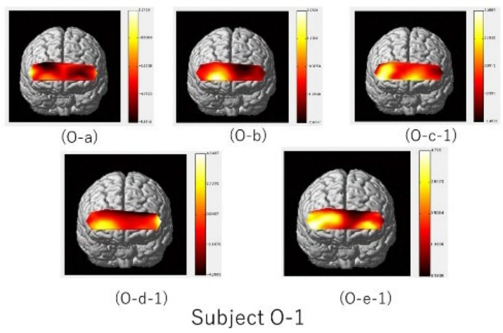

Fig.1 Advanced Brain image

In addition, processing information by learning from experience may allow the brain to process complex tasks in the prefrontal cortex.

The differences in scores are common regardless of the experience. It is thought that the optimization of game play compared to past records is the result of learning from past scores. It is observed that activating thinking and executing brain activities may have improved scores as a result of this optimization. Considering the idea of Turkel, it is regarded that the difference in brain activity by skill level may result from the difference in brain processing due to the difference in "attention".

5. Conclusion

This study investigated the activity of the prefrontal cortex during game using NIRS equipment in order to clarifying differences in brain activity due to differences in game skill. Furthermore, the brain image mapping was performed using NIRS-SPM to indicate the areas of activity based on the measured changes in oxygenated hemoglobin in order to clarify the difference of brain activity due to difference in game skill.

The results suggest that even when experience leads to the continuous presentation of complex visual stimulus patterns, the brain tends to show significant brain activity that is actively processed in terms of working memory and self-evaluation during and after play, especially in the case of skilled subjects. As for experienced subjects, who are not the skilled player, showed significant difference in the lateral prefrontal cortex in more complex and sequential patterns, such as difficult tasks, which is particularly associated with working memory, due to more sophisticated information selection and judgment.

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Improvement of Common Power Engineering Tasks with Black-box Optimization

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Keywords: Black-box Optimization, Power Plant Control Engineering, Gas Turbine Simulation, Radial Basis Functions, Simulation Optimization

The complexity of energy systems around the world is increasing due to the challenge to provide a stable and sustainable supply of electricity, heat and other forms of energy. Therefore, modelling these systems and analyzing their behavior by simulation has become an essential part of power engineering. The scope of simulation ranges from the design of single components like the blades of a wind turbine to the analysis of the operational behavior of power plants to the simulation of an electric grid for different scenarios of output of renewables energies.

Most simulation studies are – at their core – worst- or best-case analyses. Finding the maximum or minimum of a function is – mathematically spoken – optimization. The complexity of systems and models does sometimes impede the use of the actual functional expressions for the optimization of a problem. For this case, *Black-box Optimization (BBO)* methods are the best choice for this. They enable users to optimize any function without having an insight into its inner structure. In the project "Simulation of Gas and Steam Turbine Operation", methods of BBO are applied to different use-cases in the field of power plant control engineering in order to speed up simulation-based studies. The methods are compared to identify strengths and weaknesses and hopefully find and improve methods that are applicable to a variety of different use-cases.

The study has shown that BBO can significantly reduce the number of simulations needed to identify optima for different problems compared to strategies using exhaustive coverage of all possible variations of input variables. Further, it was shown that parallelization of simulations or function evaluations clearly reduces the runtime of the corresponding BBO algorithms. In addition to that, quantization of the input variables (defining a minimum step width for each input parameter) increases the efficiency of algorithms, especially considering that for most engineering tasks the accuracy of the parameters is limited in reality. Nevertheless, some methods have the downside to keep optimizing until a predefined number of simulations is reached, even if the found optimum does not improve further.

The algorithms and findings presented in this study are relevant to all engineers or scientist working with computationally expensive simulations or solving problems with an unknown or complex inner structure.

The algorithms used in this study were selected from corresponding reviews, e.g., Larson, Menickelly and Wild [1], Rios and Sahinids [2], Neumaier [3] or Custodio, Scheinberg and Vicente [4]. The selection was based on several aspects: the variables of the problems addressed in his study mostly have upper and lower bounds that algorithms must take into account. Further models representing real world phenomena may deal with noisy inputs and outputs which also is an obstacle the algorithms need to cope with. Most importantly, algorithm must identify a global optimum (within the space spanned by the variables) rather than just any local optimum.

Methods that fulfill these criteria and are easy to be implemented within the existing simulation environment are tested first on simple or simplified examples: a) *determining the maximum rotational speed of a gas turbine after a load rejection event considering three input parameters* and b) the *identification of the coefficients of a transfer function by measured data*.

In the paper [5] the following three methods are applied to the use-cases mentioned above: the *Multilevel Coordinate Search* [6] *(MCS)* by Huyer and Neumaier, where the overall search space is split into boxes along the coordinate axes. Each box corresponds to a base point with a function value that is used to decide which box should be split next by the expected improvement of the currently determined optimum. Additionally, relatively large boxes are chosen to be split to guarantee that the whole solution space is covered.

Huyer and Neumaier have also developed the *Stable Noisy Optimization by Branch and Fit* [7] *(SNOBFIT)*. For this algorithm, the search space is also divided into boxes where the base points are used for global and local approximation and the approximation functions are then used to identify where better solutions for an optimum could possibly be. Again, large boxes are split occasionally to assure the global aspect of the optimization.

Knysh and Korkolis published *blackbox – A Procedure for Parallel Optimization of Expensive Black-box Functions* [8]. In their method, an approximation by radial basis functions (RBF) is built with initially computed points. This approximation function is repetitively optimized with the condition that the found optimum must not be located within a certain radius around each known point. This radius is reduced over the iterations and the optimization is thereby shifted from a global to a local search.

For the simple examples, all algorithms provide equally good solutions (see Fig. 1). Nevertheless, MCS has a way longer runtime because of its sequential structure while SNOBFIT and blackbox compute several candidates for a new optimum in parallel. SNOBFIT is even faster than blackbox as it deploys the aforementioned quantization of the input variables. blackbox is still very interesting as it should be competitive to SNOBFIT when using quantization and it presents a computationally cheap approximation function of the actual Black-box function that could be used afterwards.

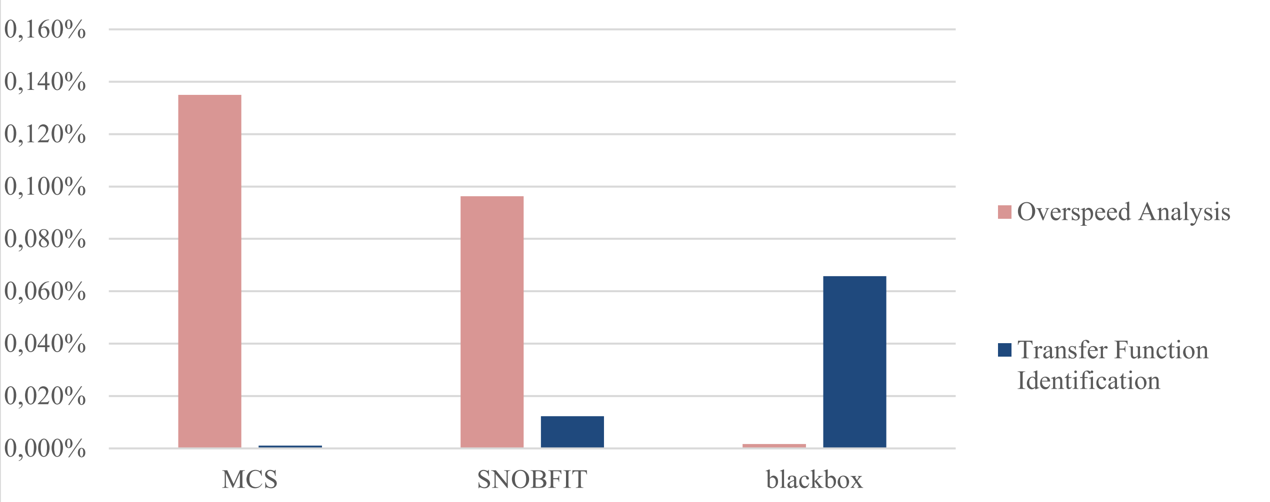

Fig. 1 Error of the Optimum Determined by the BBO Methods

As a first application of BBO to more complex problems, blackbox was compared to another algorithm using RBF by *H.M. Gutmann* [9]. The complete comparison can be found in [10]. Both methods were applied to a full analysis of the maximum speed of a gas turbine shaft after a load rejection with seven input parameters. In addition to that, three different basis functions (linear, cubic, thinplate spline) were used to approximate the true objective function. Even for this example with more dimensions both algorithms found very similar optima using just 300 simulations (see Fig. 2). The approach of computing equally distributed points in the search space would approximately have taken about 1000 simulations. Gutmann's algorithm does not use parallel function evaluations / simulations and blackbox is therefore by the number of parallel simulations faster. It is interesting that after about 120 simulations, the found optimum for the Gutmann algorithm does no longer improve (see Fig. 2 right). This means that the last 180 simulations are unnecessary, and the algorithm could have stopped earlier.

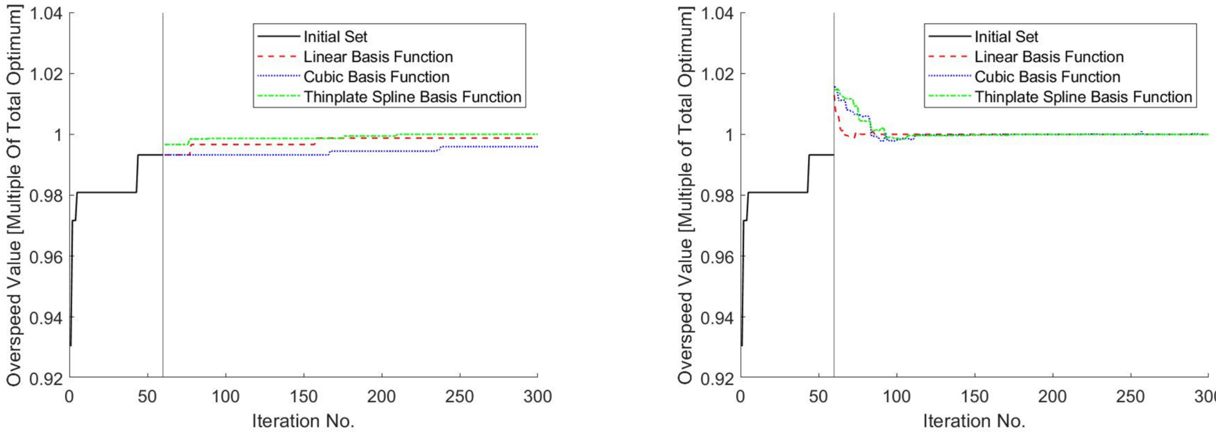

Fig. 2 Development of the Determined Optimum over Iterations for the Algorithms by Knysh and Korkolis (left) and Gutmann (right)

The last point mentioned aspect in the previous paragraph directly leads to the next part of the project: developing universal stopping criteria for the algorithm to prevent them from needless evaluations of the objective function. In combination with the realization of the quantization of input variables, the efficiency of the algorithms will be significantly improved. Nevertheless, the evaluation of new algorithms and the application to more use-cases will help identifying which method and which algorithmic parameters serve best to solve optimization problems in power engineering.

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HOCHSCHULE HANNOVER UNIVERSITY OF APPLIED SCIENCES AND ARTS

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Human-entrained embodied interaction and communication technology

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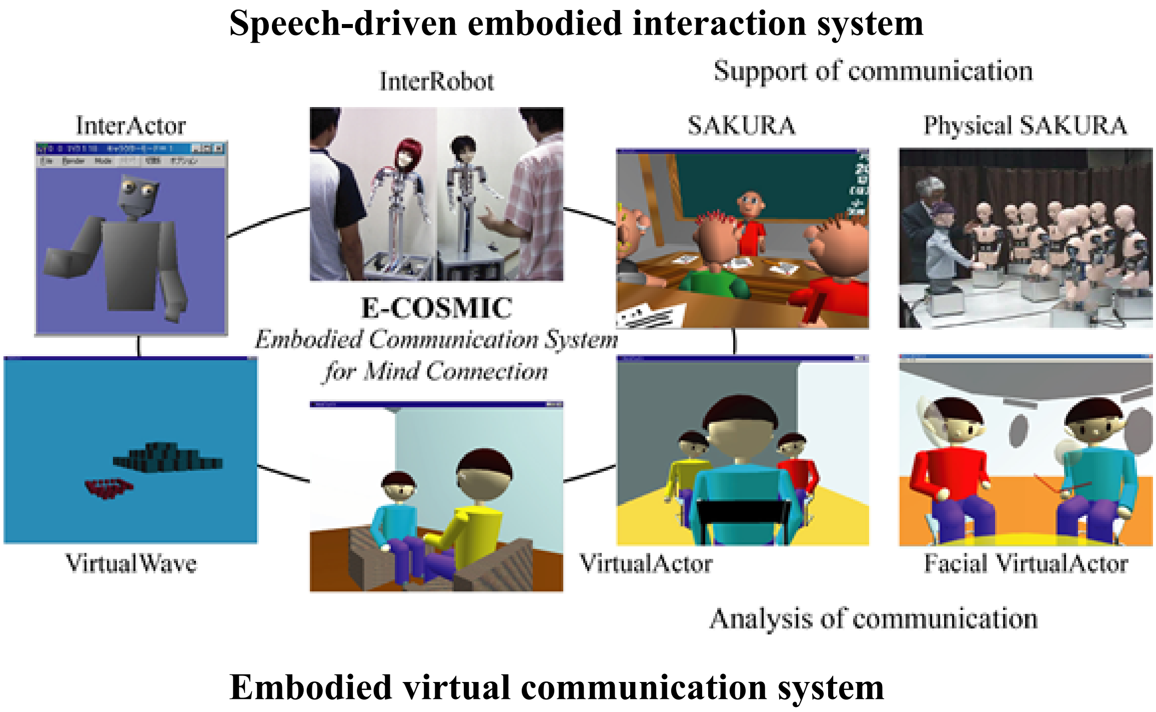
Keywords : Human Interface, Human Interaction, Embodied communication, Entrainment

In human face-to-face conversations, rhythms embodied between utterances and body movements such as nodding are mutually synchronized not only between talkers but also within talkers. This synchronicity, called entrainment in communication, creates a shared embodiment of human interaction and plays an important role in human interaction and communication. Focusing on the embodied entrainment, we have developed a human-entrained embodied interaction and communication technology that synchronizes people by applying the entrainment mechanism of embodied rhythms of nodding and body movements to verbal communication of physical robots and CG characters [1]. In particular, E-COSMIC (Embodied Communication System for Mind Connection) synthesizes and analyzes embodied communication, and automatically generates communication movements and actions from voice, and has been put to practical use in a wide range of applications, such as communication robots, toys, media content, e-learning, and game software, including education, nursing care, and entertainment. The sense of unity and sharing of this technology supports a sense of well-being and security, and is the cornerstone of the human interface that connects people. From the viewpoint of human interface in an advanced media society and a super-aged society, the human-entrained embodied interaction and communication technology is introduced as a basis for human essential communication.



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HOCHSCHULE HANNOVER UNIVERSITY OF APPLIED SCIENCES AND ARTS
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Conceptual framework for assessment of value-in-use

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Keywords: Value-in-use, Value assessment, Behaviour, Function, Model-based systems engineering

In recent years, product commoditisation has progressed rapidly, owing to market globalisation and the rapid development of technology. Consequently, the competitive landscape has changed. In these market circumstances, it is difficult for manufacturing companies to maintain or regain market share and achieve long-term growth based only on higher-quality and lower-price strategies, which was the case in the past. Against this background, the essence of the value of products and services (artefacts) is reinterpreted as being evaluated by the user when the artefact is used, rather than the high performance or quality of the artefact itself. This type of value is called value-in-use [1]. Value-in-use is evaluated based on the users' subjectivity in their own context; thus, it is an uncertain element in the design phase. Therefore, to design for the purpose of improving value-in-use, information circular design, which suggests the cyclic design process such as providing the artefact, reflecting it based on the user's information, and redesigning it, is pivotal [2]. However, as the concept of value-in-use is ambiguous, it is not easy for designers to reach a common understanding of value-in-use. This prevents the organisational practice of information circular design, in which design objects are reflected to improve value-in-use.

To solve these problems, this study focuses on the concept of model-based systems engineering (MBSE) [3]. MBSE is an approach that considers a complex design object as a system, graphically represents it as a whole, and shares it with designers in each department. This approach is expected to facilitate communication among designers in cross-disciplinary areas, thereby enabling various benefits, such as optimising the entire system and promptly responding to design rework. MBSE ensures traceability between components by graphically representing the relationships between the components of the system. Therefore, even when design changes occur, the relevant components can be efficiently identified, and the rework of the design can be efficiently allocated to each designer. Such an MBSE approach is expected to benefit organisational practice by improving the value-in-use of complex artefacts. However, MBSE does not have a method for analysing the use values determined by the user's subjectivity. Therefore, the information circular design for improving value-in-use in MBSE is not easy to implement.

Based on these backgrounds, this study proposes a conceptual framework that describes the concepts and relationships underlying the value-in-use concept and attempts to formulate value-in-use based on this conceptual framework. By using this framework, the designer can graphically model the artefact and the user, thus providing a basis for realising a common understanding of value-in-use. Additionally, the proposed conceptual framework enables traceability. Thus, the proposed conceptual framework is expected to support the identification of important factors to improving value-in-use. Furthermore, by attempting to formulate value-in-use based on the framework, this study provides research direction for calculating the value-in-use. If a detailed method for calculating value in use can be developed in the future, it is expected that it will be possible to efficiently identify design details that should be considered to improve the value in use. Thus, this study contributes to the value-in-use assessment. Future work will include the development of a practical procedure for graphically describing concepts and their relationships underlying value-in-use using the conceptual framework, and a detailed study of methods for calculating value-in-use, thereby establishing a method for assessing value-in-use.

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Conflicting goals in the development of washing machines

approaches to solutions with engineering methods

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Keywords: Big data, Parameter estimation, Artificial intelligence, Smart home, Product development

Development History

The development of the first washing machine dates back to 1767. At that time, the drum was made of wood and driven by muscle power. Today, a washing machine is a complex device with controls and sensor technology [1].
Development cycles are becoming shorter and shorter, and price pressure from low-wage countries is increasing.

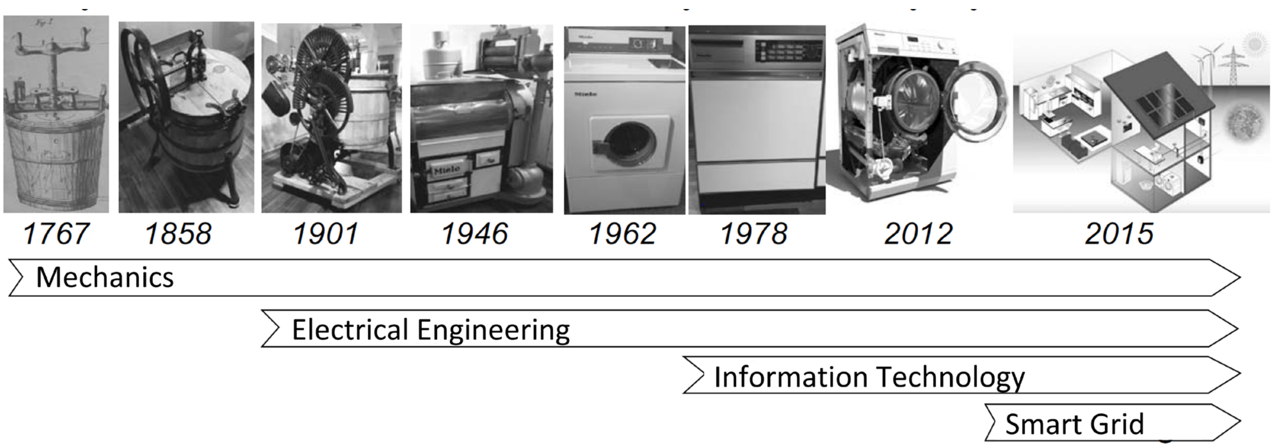
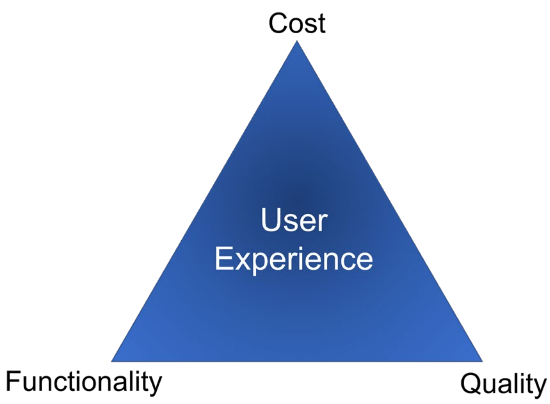


Figure 1 Development of washing machines [1]

Initial State

Any kind of product development comes with contrary goals like developing a smart interconnected device and at the same time reducing its cost. These goals can be mapped with a Magic Triangle and together they form the User-Experience for the product.

When it comes to newly developed household devices the costumer wants them to be "smarter", cheaper and he wants to have an overall better experience. Satisfying every aspect seems to be impossible.



Problems

Smarter often means remote controlling with your mobile phone, seeing every data the machine acquires, being able to self service the device and more.

1. To collect data your device needs sensors and microcontrollers to read them. Every sensor and controller increases the manufacturing cost. Any price increase makes you loose market share to a competitor. This is a special challenge on the consumer market where your manufacturing cost is as example 500€, buying two sensors for 5€ means an increase by 2%. For a milling machine with 100k manufacturing cost, the price increase is 0,01%.
2. In addition, the processor performance is currently tightly calculated for cost reasons. The current processors cannot process any more data or even store and analyze it.
3. Right now, the Customer needs to call the customer service hotline to get a replacement in several weeks. If the customer wants to self-service his machine, he needs to know exactly what the given error number means and if he can fix the problem by himself. Providing this information with a hotline service causes high running costs.

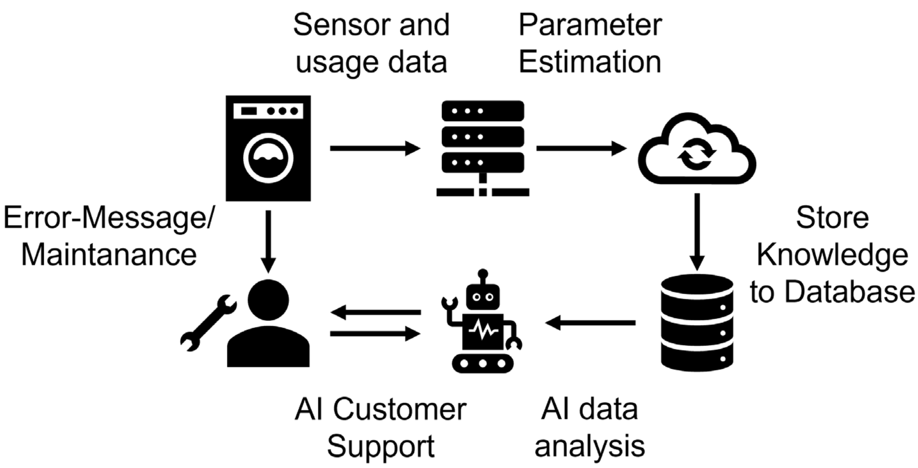
Solutions

To satisfy the user in all aspects, current technologies from engineering can be used.

1. The installation of new sensors is excluded due to price pressure. In order to collect the required data, a methodology from feedback-control engineering can be used. The missing parameters are estimated with a Kalman Filter, which is used in robotics and other fields [2, 3]. The standard Kalman filter is intended for parameter estimation in linear systems. However, the latest developments in control engineering also allow simple parameter estimation for nonlinear systems like washing machines, using a sigma-point Kalman filter [3].

2. Because the processors in the washing machines are limited in performance for cost reasons, the required computing power can be outsourced to central servers. The servers can analyze the data and build a knowledge base from usage data and error messages from the machines.

3. An artificial intelligence can then provide the user with appropriate assistance based on the knowledge database without long waiting Times on a phone hotline for the user and high running costs for the manufacturer.



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Development of an Embodied Avatar-Agent Dialogue System to Support Communication Education for Clinical Engineer Students

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Keywords: Embodied interaction, Communication Education, Agent, Avatar, OSCE

Abstract

Currently, there are few opportunities to develop communication skills in clinical engineering training schools in Japan. Therefore, we developed a system to interact with an agent equipped with a rule-based chatbot, which was created with reference to the objective clinical competence examination (OSCE). In this study, we added an avatar that reflects the user's embodied movements to the system. In the virtual space created, the agent playing the patient, equipped with a rule-based chatbot, responds to the user's voice, and the avatar uses a webcam to project the user's body movements in real time. The avatar, which reflects the user's body movements, exists in the same space as the agent, allowing the user to view his or her own body movements objectively. This allows the user to obtain more information and is expected to have a highly educational effect.

1. Introduction

A "clinical engineer" is a medical professional who operates and inspects life-support systems under the direction of a physician. In Japan, clinical engineers may speak within the team about the patient's treatment plan, or lecture the staff, patient, or patient's family about medical equipment. Currently, training in clinical engineer training schools is conducted in the medical field, the engineering field, or a mixture of both. On the other hand, healthcare professionals are required to have special communication skills for patients. Practical training related to the mastery of these skills is not generally provided, and clinical engineers are forced to learn communication skills in the clinical setting. As a concept common to all healthcare professionals, communication between healthcare professionals and patients is an important element for smooth treatment in the medical field. It is called "listening," "empathy," and "acceptance" [1]. These are used to recognize and understand the patient's emotions and then output them as verbal or non-verbal information. One of the ways to acquire these skills is to take the Objective Structured Clinical Examination (OSCE). The OSCE was developed by Harden et al. [2] and is used in Japan as a pre-clinical training test for physicians. In recent years, it has been widely introduced in the fields of nursing, nutrition, physical therapy, and other co-medical fields. The OSCE is a practical examination that involves actual communication and consultation, and the presence of a Standardized Patient is indispensable for its implementation. Testing and practice with Standardized Patient has the advantage of providing feedback from the patient's point of view without affecting the real patient, making the training realistic. The disadvantage is the cost aspect, such as advance preparation and expenses for the request. In particular, it is reported that costs account for 22.7% of the total OSCE costs [3].

To address this issue, our laboratory has developed a system in which nursing students perform role plays using avatars, and its effectiveness has been reported [4]. In addition, a system is being developed in which an agent equipped with a chatbot placed on the screen is assumed to be a patient and interacts with the patient [5].

In this study, based on the above issues and previous research, we developed a system for fostering communication skills that assumes actual clinical situations by replacing the responses of simulated patients with agents equipped with chatbot that have fixed responses.

2. System Concept

The concept of this system is shown in Figure 1. The system consists of a dialysis room in a virtual space, an agent equipped with a rule-based chatbot, and an avatar that reflects the user's physical movements in real time. The user interacts with the on-screen character as if it were a dialysis patient. The statements made by the character are pre-defined and change according to the user's statements.

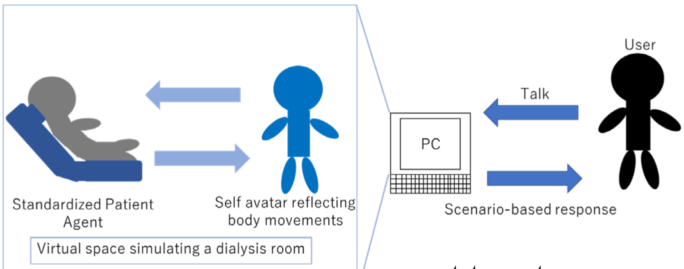

Fig. 1 System concept

3. System Composition

A diagram of the system is shown in Figure 2.The system was developed using Unity (version: 2020.3.18f1), and the patient and student characters were created using VRoid studio (version: 1.7.0) provided by pixiv.

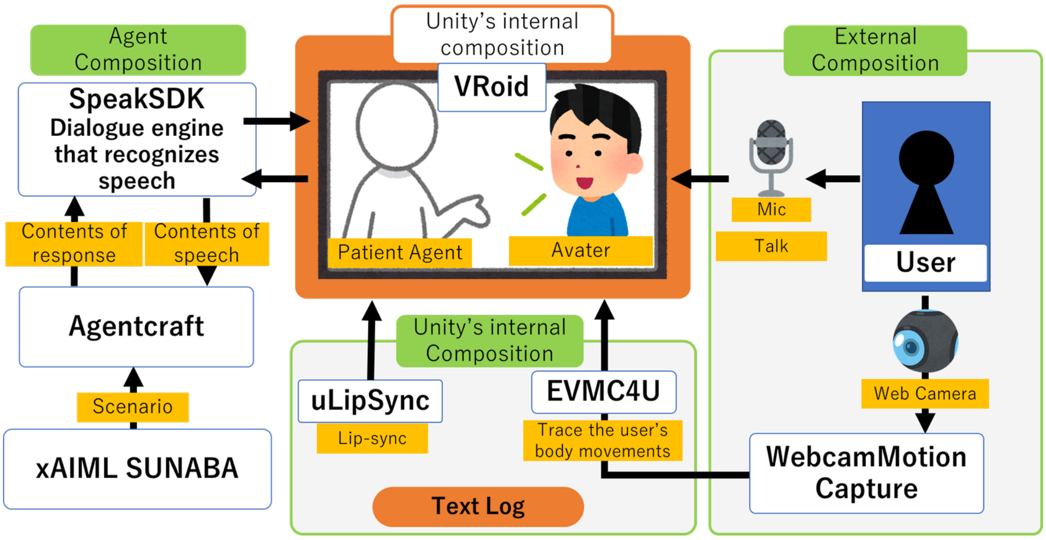

Fig. 2 System Composition

The agent part specifies the contents related to spoken dialogue. Conversation scenarios are defined by SUNABA, and speech synthesis and adjustment of speech content are performed in conjunction with Agentcraft. In addition to this, by working with a speech recognition engine speakSDK, it is possible to quickly respond to the input voice. The user, on the other hand, uses a microphone for voice input. Avatar's body movements can be reflected from the camera in real time by using an application. The body motion data was collected using Webcam Motion Capture, a tool that enables motion tracking using a camera connected to a PC.

In addition, by using Easy Virtual Motion Capture For Unity (EVMC4U), a tool that connects VR equipment and Unity, the user's movements can be reflected in Unity in real time, although there is a limitation that only the upper half of the body is used. By understanding the space while objectively viewing one's own behavior through the avatar, the user can feel closer to the agent. In addition, the Proteus effect, in which the appearance of the avatar influences the user's behavioral characteristics, as reported by Yee et al [6], is expected to enhance role-playing.

By integrating these in Unity, an environment is created in which the agent and avatar exist on the screen. The user can watch his or her own movements and engage in conversation from a third-person perspective. In addition, it is possible to output the conversation contents as a text log.

4. Dialogue scenarios

There is no Standardized Patient setting in clinical engineer that is consistent with OSCE. Therefore, we decided to assume a conversation with patients undergoing dialysis, which is the most common place of employment for clinical engineers. The scenario flow is shown in Figure 3. The scenario is based on the OSCE criteria, and the goal is for the user to find the cause of the weight gain when the patient character mentions it .The scenario is constructed in such a way that the more the user is friendly to the patient character, the more the patient character discloses information about the cause.

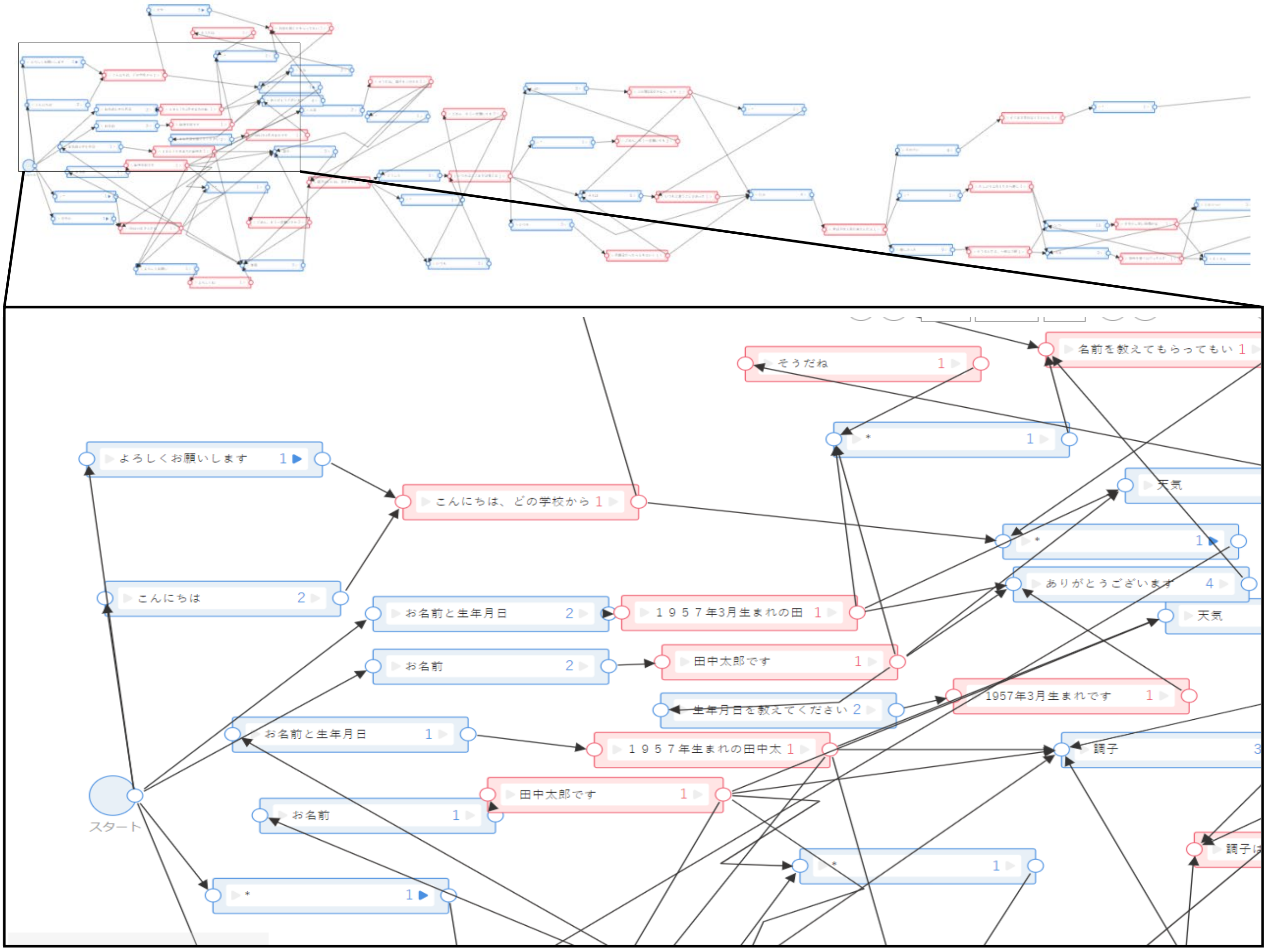

Fig. 3 Part of a scenario flow

5. Conclusion

In this study, we developed a communication education system for students who aim to become clinical engineers, in which an agent as a patient equipped with a rule-based chatbot that enables voice communication and an avatar as a student that can reflect the user's body movements in real time are placed in the same space. By using an agent as the patient, the user can practice easily, and by having an avatar that reflects the user's own body movements in the same space as the agent, the user can view own movements objectively. The system can create various situations and scenarios by preparing 3D models and scenarios in advance. By setting scenario branching conditions, the system can be developed as a single agent that can listen to the specialized fields of each profession. In the future, we plan to study a system that can be used in actual educational settings.

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Opportunities for using digital pens to improve higher education teaching

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Keywords: Education 4.0, Smart pen, Digital exams, Automatic exam correction, Software programming

1. ABSTRACT

Digital pens make it possible to digitize analog drawings and transcripts. Its currently used for digitalization in health care or to fill out different forms. Hanover University of Applied Sciences and Arts (HsH) is looking for ways to improve higher education by using the pens in teaching. Particularly exams are still mostly written in analog form and offer great potential for improvement in terms of digitization.

With digital pen, exams can be corrected in a different way, as the sequence of individual tasks, but also the entire exam, can be tracked. This could lead to a faster and better correction of exams and also improve higher education teaching in long term.

This paper presents how digital pens work. It compares the differences between existing technologies on the market and points out particularities in the use of digital pens in exams.

It also presents the architecture already in place at the HsH to perform exams. It describes what needs to be considered when creating exams that are to be conducted with digital pens. It also presents first experiences in the use of smart pens in exams.

Finally, the paper shows which tests will be carried out in the future to verify the applicability of digital pens in university teaching. Different types of tasks as well as topics are discussed.

2. CONCEPT

The technology of digital pen has been improved and optimized over the years. There are two main companies that offer smart pens. Anoto focusses on pens to be able to evaluate forms quickly, whereas NeoLab focusses on digital sketchbooks to save written data on mobile devices.

HsH focusses on opportunities for the application of smart pens in higher education teaching.

Exams, in particular, can be improved by smart pens, as these make it possible to view and evaluate the processing sequence of an exam. The prerequisite is that the processing sequence of exams can be represented in a suitable form. In this paper, various display options are examined.

This paper also focuses on the architecture for using digital pens during exams in the field of mechanical engineering, as it was written at the Faculty II of HsH. It presents experiences in initial tests and indicates which tests will be conducted in the future to indicate which type of exams can be improved by using the digital pens.

Provided that the processing sequence can be represented in a suitable form, evaluations of the individual process steps can lead to a more transparent correction of examinations. Also, the insight into the processing sequence can lead to a better understanding of the students' thinking processes and thus to an adapted and better examination correction and teaching. In addition, exams can be designed differently, so that it is possible to create tasks that cannot be corrected without knowledge of the solution steps.

Another advantage would be the digital storage of all exams. This can lead to a semi-automatic exam correction. Exams can be corrected by several examiners at the same time, as well as having exams written independent of location, since the examiner can receive the results electronically.

3. DEFINITION OF DIGITAL PENS

A digital pen can use its built-in optoelectronic sensor in combination with digital paper to calculate its exact position and thus digitally store the written data. Additionally, it is a pen that can be used to write on a paper like every other pen.

Since other smart pens weren't available at the time of purchase, HsH opted for the Lamy safari all black ncode. It is based on the Lamy safari all black rollerball, a very common pen in Germany. It consists of the following components (see Figure 1):

- **Optoelectronic sensor** to detect code on the paper (camera and infrared sensor)
- **CPU** to calculate the pen's position on the paper
- **LED display** to show the status of the pen
- **Micro USB port**
- **Pressure sensor**

The built-in optoelectronic sensor consists of two parts: An infrared light sensor and a camera. To work correctly, it needs to be combined with digital paper, which contains a special pattern. The digital paper needs to be able to reflect light waves between the wavelength of 800 and 950 nm, whereas the paper's ink needs to be able to absorb these lightwaves. This ensures that the infrared sensor can detect the printed dots on the paper.

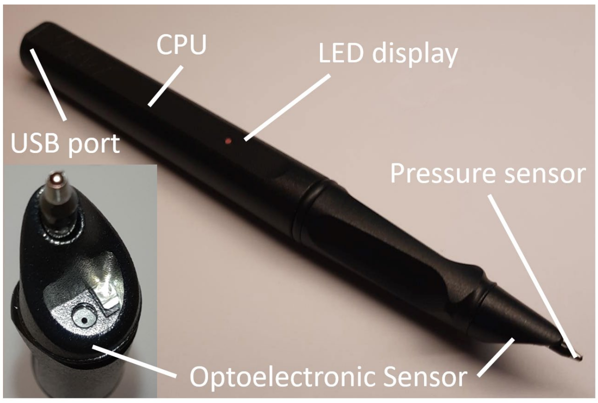

Figure 1: Lamy safari all black ncode

The optoelectronic sensor can only detect the position code on the paper. It cannot detect the ink applied to the paper by the pen. [1]

The way to digitally save written data was first developed by the Swedish company "Anoto". The "Anoto" digital paper consists of a collection of dots individually distributed over the entire page. The pen is thus able to calculate its exact position from a small area, using a built-in infrared sensor to detect those dots. Figure 2 (left side) shows this small area of 6 by 6 dots. Each dot has four possible positions with respect to the line pattern in the background. In an area of 6x6 points, there are $4^{6 \cdot 6} = 2^{72}$ possible combinations. The distance between two lines is 0.3mm. Therefore, this method could cover an area of 60 million square kilometers without repeating the same pattern.

The resulting patterns are organized into what are called segments. Each segment contains shelves that contain books, which in turn contain pages. Every possible combination of dots is associated with a certain page and a certain coordinate. Therefore, each page is different from another. The collection of dots individually distributed over an entire page is also called the digital paper's pattern template.

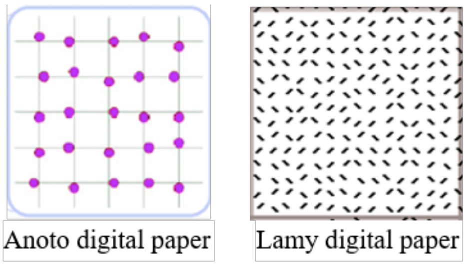

Figure 2: Special Pattern to detect pencil location, see [5]

Lamy uses the same method of calculating the pen's position, but the digital paper consists of lines. These lines can also be placed individually with respect to the line pattern. Additionally, they can be aligned in different ways (Figure 1, right side).

While writing with the pen, the CPU calculates its x-y coordinates by processing the sensor data of the optoelectronic sensor and stores the pens path inside. The optoelectronic sensor generates data continuously by taking snapshots at regular time intervals. For each snapshot, a time stamp is stored in the pen, which contains information about:

- Position of the pen (x-y coordinates)
- Writing angle
- Tilt
- Pressure in the pens tip
- Exact time

The pressure in the pen tip is used to detect whether the pen is actually being used for writing. The data that is recorded between a pen set down and a pen pick up are called stroke data.

When the collected time stamps are transferred to an external device, each data contains the pen's ID. [1]

4. ARCHITECTURE

The modus operandi to execute exams with digital pens is as follows:

1. exam design
2. document processing for digital exam
3. printing
4. exam writing
5. pen data readout and rendering based on exam document
6. exam correction with pdf annotations (automatic

processing of data)

7. exam archiving of the pdf with exam correction

First, the exams must be created according to a certain pattern described in the following. This ensures that the exam data can be digitally saved and corrected afterwards. Under each task, a predefined edit field (see Figure 3; 2) must be created in which the students can edit the task. After the exam, the pen data (see Figure 3; 3) will be displayed here and can be corrected directly in the edit field. Then it must be exported to create the raw exam PDF file.

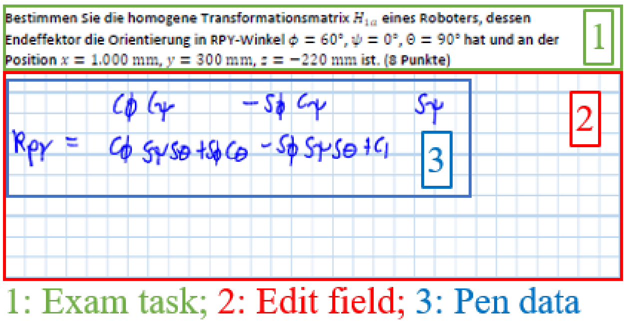

Figure 3: Example of an exam task (Task 1 of "Robotics", Prof. Jens Hofschulte, HsH)

Then, the raw exam PDF needs to be merged with the digital papers pattern template to create the digital exam PDF file. There are two ways of merging the exam. The pattern template can be inserted into the edit field, or the pattern template can be deposited on the entire exam page. As sometimes the edit field is too small for a student handwriting, the second option allows them to use every part of an exam page.

It is important that a different part of the pattern template is used for each page in an exam. Otherwise, the pen will not be able to match the student's handwritten answers to the corresponding task. To simplify printing, every exam has the same pattern template. The same templates for different pens cannot lead to confusion since the pens are evaluated individually. Because the exam PDFs cannot be distinguished, it is very important to be able to assign the pens to individual students. To do this, the pen ID can be read before it is issued to a student, or different barcodes can be applied to the pens.

The digital exam PDF file also needs to be merged with meta data. Meta data defines scoring location and the maximum achievable score for a task. Meta data is used in the evaluation of the pen data after the exam to assign it to the individual tasks. It is also used to enable semi-automatic exam correction. In Figure 3, the edit field would be assigned to task 1a. Also, a maximum number of 8 points would be defined for this task.

After creating the exam PDF file, it must be printed afterwards. It should be noted that the ink reflects light waves in the range of 800 to 950 nm to ensure compatibility with the digital pen. This is achieved by printing with color laser.

After the exam is written, the pen data is evaluated and merged with the exam PDF to create the written exam PDF file for each student.

The pen data is first assembled into polylines, which consist of the individual snapshots of the pen. Each polyline begins when the pen is put down (start of writing) and ends when the pen is picked up again. The pressure sensor detects when the pen is put down and taken up.

For static rendering, the meta data in the exam PDF is used to assign the polylines to the individual pages and tasks. This allows you to switch between the pages in the solution PDF that are the last to display the respective task in terms of time. The buttons thus make it possible to switch between the final results of the respective task.

For time rendering, the polylines are split by time and divided into time segments of 3 seconds each. For each of these time segments, a page is generated in the result pdf, which displays all polylines of the current page up to the time interval under consideration (see Figure 4). If a student first processes task 1, the processing of this task is shown in time segments of 3 seconds. If the student then switches to another task, the processing of this task can be seen on the solution PDF. If the student switches back to the original task 1, the solution PDF again shows this page with all the previously displayed polylines.

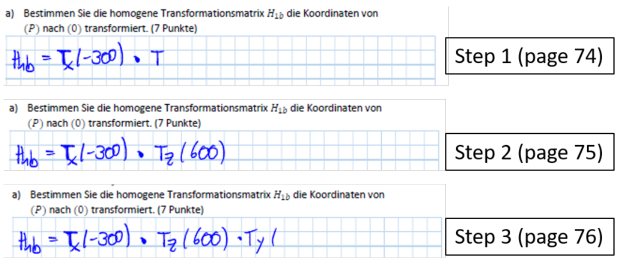

Figure 4: Example for time rendering: different pages of result PDF (Task 1 of "Robotics", HsH)

In addition to static and time rendering, the meta data can also be used for semi-automatic exam correction to create a solution exam PDF. The examiner can insert points as annotations on any page, e.g. in any processing step of the student's work, which are automatically combined at the end into a total score and thus into a final grade. The aim is that the points are always inserted when a further partial solution is added in the respective processing step.

After the exam has been corrected, the solution exam PDFs are automatically saved in PDF A format and archived.

5. INITIAL TESTING

In order to gain initial experience with the smart pen, tests were conducted with various HsH participants as well as distance learning students.

"Robotics" exam from 2019 (see Figure 3) includes different types of tasks. Therefore, this paper is ideal to be used as the first test with the digital pens. There are drawing tasks and tasks where students have to calculate a scalar quantity by using matrices. There is also a multiple-choice task.

The following problems were encountered when testing the pen for the first time. During the exam, the students need to make sure that the pen is activated and running by checking the pen's LED display. Otherwise, the pen will not record the first few minutes of the student's writing.

Also, in some cases, the sensor was obscured because a ruler was used for drawing. For some tasks, a pair of compasses must be used. Here, the drawn line must be traced afterwards with the digital pen. Another possibility would be to provide a compass in which the digital pen can be mounted.

In one case, the digital pen was pressed too hard, and it got destroyed. It is therefore necessary to be able to assign several pens to one student. Nevertheless, there is still a risk that the defect of a pen will not be detected until after the exam. Then the exam must be corrected on the basis of the described pages.

After processing the data of all participants, the processed PDF files total between 300 and 600 pages. This depends on the participants and the number of polylines, i.e. the frequency with which the pen was lifted.

6. DISCUSSION AND FUTURE WORK

The Lamy smart pen requires further testing to verify its applicability in exams. The smart pen could potentially be used in various fields at the HsH:

- Technical Drawing (how do students draw a side view of a given object, do they follow a certain pattern?)
- Mechanical Engineering studies: students often have to follow given instructions (e.g. machine parts)
- Mathematics Exams

The pen needs to be tested on various exams to identify areas that can be improved. The goal is to test them with multiple choice tasks, arithmetic tasks and technical drawing tasks. After that, the pen needs to be tested over a longer period of time to assess its potential in improving teaching in higher education. It must be analyzed which exams can be adapted to better utilize the potential of the smart pens.

Last, smart pens could be used for transcripts in verbal exams. The order of the verbal exam and the answers of students could be viewed afterwards and included in the evaluation.

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HOCHSCHULE HANNOVER UNIVERSITY OF APPLIED SCIENCES AND ARTS

OKAYAMA PREFECTURAL UNIVERSITY

Frequency analysis of Wi-Fi received signal strength using Lomb-Scargle periodogram

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Keywords: Wireless LAN, Sensing, RSSI, Spectral estimation, Lomb-Scargle periodogram

Wi-Fi sensing is expected to be a low-cost sensing technique because it does not require dedicated sensors [1-7]. Various signal processing methods have been proposed for Wi-Fi sensing, depending on the signal type to be used and the target to be sensed, for example, the received signal strength indicator (RSSI) estimates the distance between devices based on the RSSI magnitude [1, 2], the channel state information (CSI) that used in MIMO (Multiple-Input/Multiple-Output) transmission is used for behavior identification and personal identification and deep learning is the mainstream data processing method for this purpose [3-7]. Spectral analysis should be useful when the detection target has periodicity, but the sampling interval of RSSI time-series signals is generally irregular, and the well-known Fourier analysis cannot be applied as it is.

In this study, we applied the Lomb-Scargle periodogram [8], which is known in the field of astronomy as a spectral estimation method for data with irregular sampling intervals, to RSSI signals to investigate the detection of periodic motion.

Figure 1 shows the experimental setup. A wireless LAN router (tp-link Archer AX73) and an adapter (ALFA AWUS036ACH) were placed 120 cm apart as a transmitter and a receiver. The router was configured to have a fixed beacon interval of 100 ms and a fixed channel 36 (5.18 GHz). The frames originating from the router can be captured in monitor mode using the network analyzer software Wireshark.

A metal bookend was manually moved back and forth between the antennas as shown in figure 1 in four types of cycles those were 4 seconds, 2 seconds, 1.5 seconds and 1 second, thus, the frequencies of the motion were 0.25 Hz, 0.5 Hz, 0.67 Hz and 1 Hz, respectively. The beacon signals output from the router were acquired for approximately 3 minutes without any motion and with reciprocating motions, respectively. The reciprocating motions were synchronized with a metronome to keep the rhythm as constant as possible.

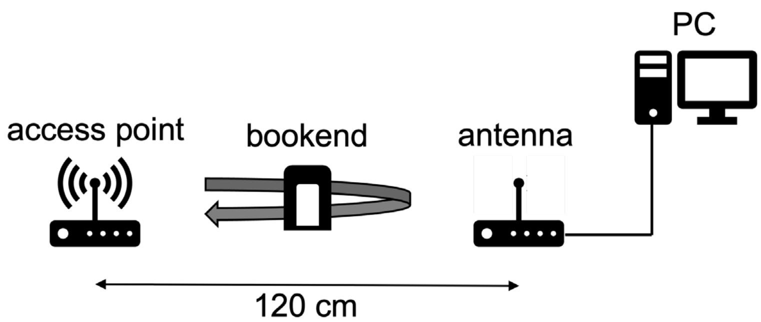

Figure 1. Experimental setup

Figure 2(a) shows the time series of RSSIs of steady state and periodic motion of 0.25 Hz ~ 1 Hz respectively. The signal fluctuates greatly when a reciprocating motion is performed compared to the steady state case, but it is difficult to find a difference in the motion cycle. Figure 2(b) shows the results of spectral estimation using the Lomb-Scargle periodogram. It is considered that the frequencies of motions were clearly detected by the spectral estimation. The harmonic peaks were also observed in each case, which may indicate that the periodicity was distorted by the manual motion.

In summary, spectral estimation of received signal intensity during periodic motion in the propagation path was conducted as an investigation of signal processing methods for Wi-Fi sensing. Lomb-Scargle periodogram was used to estimate the spectra, and the results showed that the peaks in the spectra were consistent with the frequency of motion, suggesting the usefulness of spectral estimation.

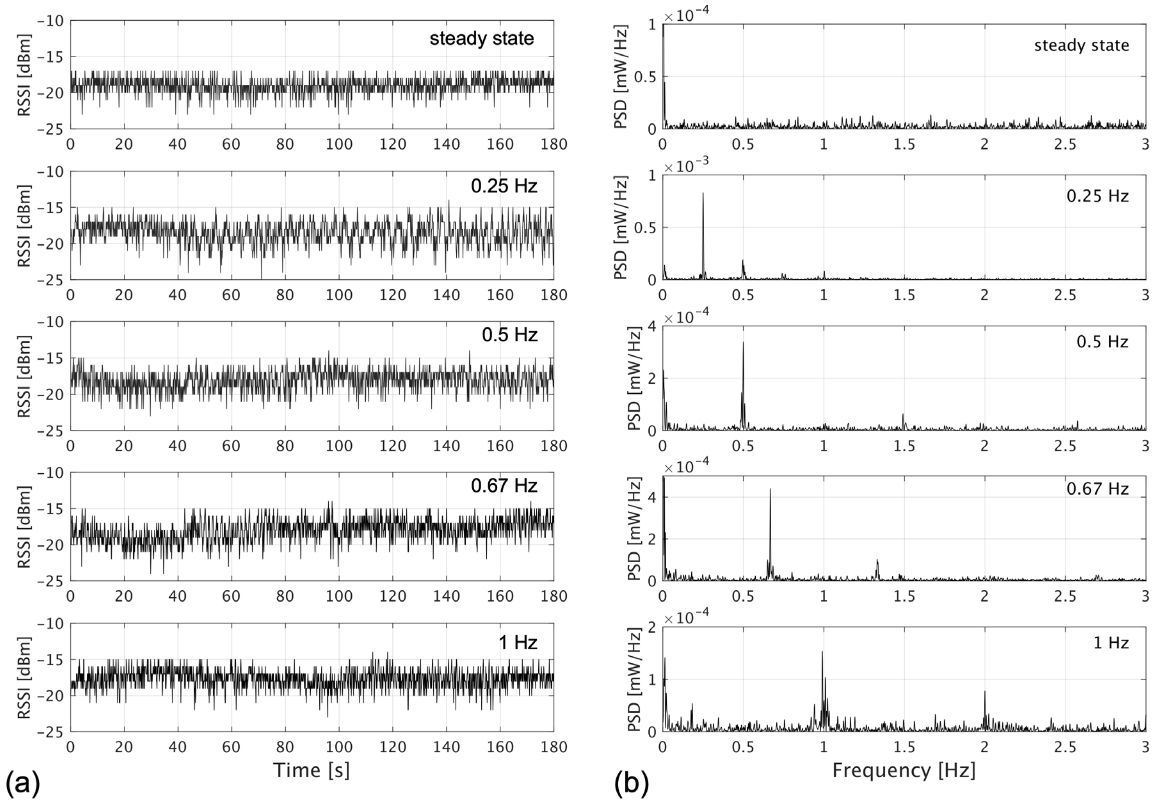

Figure 2. Time series signals and spectrum estimation results

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Simulation of the electronic part of Mößbauer spectroscopy

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Keywords: Mößbauer spectroscopy, Transimpedance Amplifier/Converter, Space Analytics

In light-processing systems, light energy is converted into a photocurrent due to the photoelectric effect. Since signal processing can only be performed after downstream voltage conversion, analog circuit development is essential. The goal of this project is to develop a high-precision energy-to-voltage conversion circuit to optimize signal processing in light-processing systems with application in space analytics (Mößbauer spectroscopy).

For this purpose, several circuits for voltage conversion are developed, optimized and compared. The development involves operational amplifier and transistor circuits. Filters are added for optimization, which lead to a significantly better signal-to-noise ratio and improve the signal quality. This paper is the introduction to the system of development in this area and represents the first of several elaborations.

1. Transimpedance Amplifier & Fourier Transform

The photocurrent i_{ph} (t) is converted and amplified into a voltage u_a (t) [1]. At this point the frequency response of the system can be specified out of figure 1:

$$\underline{G}_{TP2}(j\omega) = \frac{K_P \cdot \omega_0^2}{\omega_0^2 - \omega^2 + j\omega \cdot 2D\omega_0} \qquad (1)$$

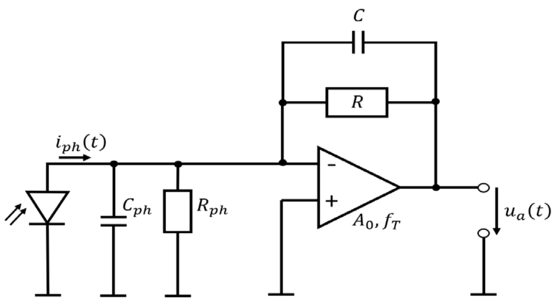

Fig. 1 Transimpedance Amplifier

Equation (1) describes the transfer function of the electrical system as the Fourier Transform and brings it into a standardized form. It is a second order (n = 2) low pass. From here, the floor diagram, locus, and other methods can be used to analyze the system [1],[2],[3].

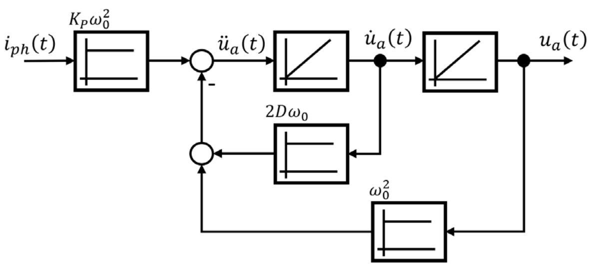

Fig. 2 Block Diagram of a Standardized Transimpedance Amplifier

2. Laplace Transform & Block Diagram

Another more common version of the standardization is the Laplace Transform of the system

$$G_{TP2}(s) = \frac{K_P \cdot \omega_0^2}{s^2 + 2D\omega_0 \cdot s + \omega_0^2} \qquad (2)$$

Figure 2 shows the Block Diagram of the system and opens up a better view into the inner dynamics of the process. For reasons of simplification, interference signals and noises have been omitted. However, these can be added to the input or elsewhere in the diagram as desired.

Now it is possible to switch to classical control theory or to state-space control. This article takes a closer look at state-space control. The Laplace Transform of the amplifier allows faster determination of the system's differential equation and represents a transition to the state space. Furthermore, this form of description enables the entry into the simulation (fig. 3) [2],[3],[4].

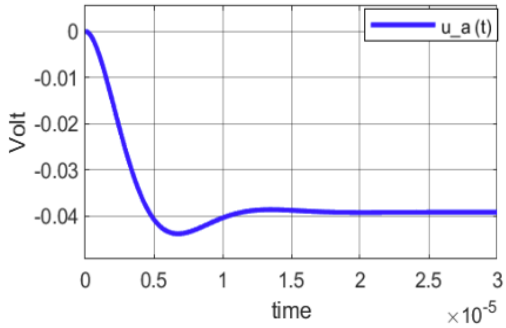

Fig. 3 Step Response of the System

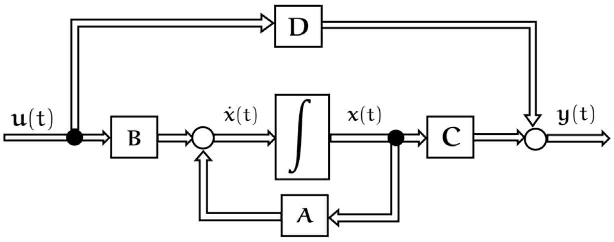

Fig. 4 Block Diagram of a Standardized Transimpedance Amplifier

3. State Space Model

The state space model or description of the system (fig. 4) opens up a whole range of further and, above all, multidimensional control opportunities.

First of all the controllability can be investigated using Q_{Con} [4],[5],[6].

$$\dot{x} = A \cdot x + B \cdot u \qquad y = C \cdot x + D \cdot u \tag{3}$$

$$Q_{Con} = \begin{bmatrix} B & A \cdot B & \dots & A^{n-1} \cdot B \end{bmatrix} \tag{4}$$

$$\text{rank}(Q_{Con}) = n \tag{5}$$

4. State Controller

The state controller **K** feeds back each state under scalar change and in this way it shifts the eigenvalues of the system (fig. 5). Since the system has only one input signal, it is sufficient to design **K** as a singlerow control vector **K** → $\mathbf{k}^T$ and V becomes a scalar value **V** → v. The feed forward control v of the system is used to scale the output signal as desired [4],[5],[7].

$$t_{R,1}^T = [0 \; 1] \cdot Q_{Con}^{-1} \tag{6}$$

$$P_\alpha(\mathbf{A}) = \alpha_0 \mathbf{I} + \alpha_1 \mathbf{A} + \dots + \alpha_{n-1}\mathbf{A}^{n-1} + \mathbf{A} \tag{7}$$

$$P_\alpha(s) = (s - s_{p,1})(s - s_{p,1}) \dots (s - s_{p,n}) = \alpha_0 + \alpha_1 \cdot s + \dots + \alpha_{n-1} s^{n-1} + s^n \tag{8}$$

$$\mathbf{k}^T = \mathbf{t}_{R,1}^T \cdot \mathbf{P}_\alpha(\mathbf{A}) \tag{9}$$

By suitable selection of α_i or poles of the system, the dynamics can be directly influenced.

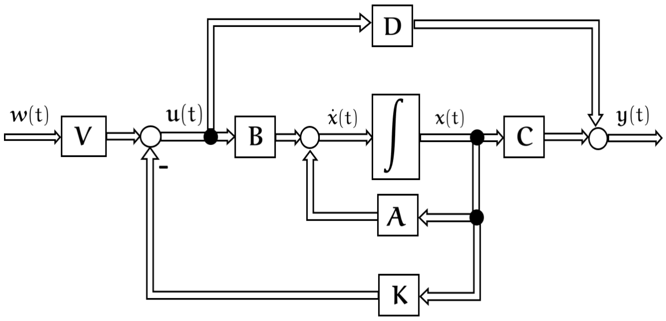

Fig. 5 State Space Model & Controller **K**

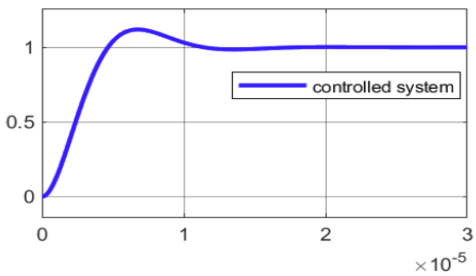

Fig. 6 State Controlled System

5. Pole specifications

In order to find suitable poles, two pole pairs are now compared with each other as an example. On the one hand, the poles of the original system are specified again to confirm the influence of the prefilter. On the other hand, other poles are specified in order to consider the overall system. The second pole pair lies a little further on the left half plane of the Laplace or eigenvalue plane. This is to ensure sufficient stability of the system.

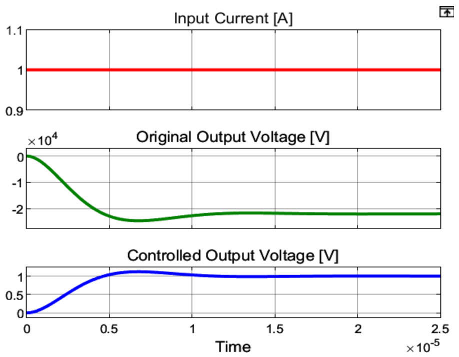

Fig. 7 controlled system response with original poles

Original system

$$\lambda_{1,\,old} = (-3.1510\ - j \cdot 4.6541) \cdot 10^5$$
$$\lambda_{2,\,old} = (-3.1510 + j \cdot 4.6541) \cdot 10^5$$

$$v = [\boldsymbol{c}^T \cdot (\boldsymbol{b} \cdot \boldsymbol{k}^T - \boldsymbol{A})^{-1} \cdot \boldsymbol{b}]^{-1} \approx -4.538646575609222 \cdot 10^{-5}$$

The step response of the controlled system is normalized to the value 1 and keeps the harmonic and the original behavior mirrored. The transient response is close to $1{,}0 \cdot 10^{-5}$sec.

Controlled system

$$\lambda_{1,\,new} = (-7) \cdot 10^5$$
$$\lambda_{2,\,new} = (-8) \cdot 10^5$$

$$v = [\boldsymbol{c}^T \cdot (\boldsymbol{b} \cdot \boldsymbol{k}^T - \boldsymbol{A})^{-1} \cdot \boldsymbol{b}]^{-1} \approx -8.045918993125406 \cdot 10^{-5}$$

There is no longer an oscillation with harmonic characteristics. The transient is now below $1{,}0 \cdot 10^{-5}$sec and faster than before.

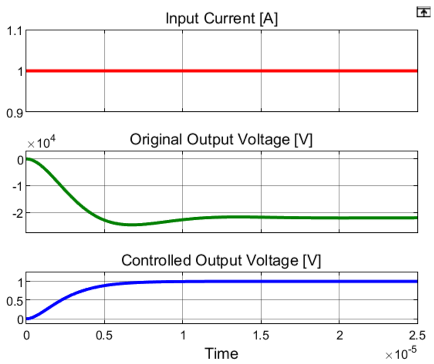

Fig. 7 controlled system response with new poles

6. Conclusion and Outlook

A state controller can positively influence the system behavior of an electronic system such as the transimpedance amplifier in terms of better transient response. The output signal is normalized to 1 by means of the pre-filter and can be held at the stable final value for a suitable time for real-time processing. Next, feedback signals decoupled from the circuit, should be developed with respect to the feedback vector. For this purpose, an observer design is helpful to estimate signals that cannot be measured.

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First-principles calculations and their application to the field of semiconductor materials

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Every matter is composed of atoms and has a particle-wave duality. An atom consists of a nucleus and electrons. Such extremely small particles do not obey the classical laws that we are familiar with in our daily lives. This is because the wave nature of particles cannot be ignored due to their small mass. The science of these particles is called quantum mechanics.

First-principles calculations are based on the fundamental principles of quantum mechanics and focus on the many-body systems of atomic nuclei and electrons that make up materials. This method provides information on physical properties through theoretical calculations without the use of experimental data. In addition, the accuracy of the calculations is almost identical to the experimental results, and there is no need for experimental facilities, making it useful in a wide range of fields on materials for batteries and semiconductors, fertilizers for agriculture, refrigerants for air conditioners, etc. Particularly in the field of semiconductors, it has been well-known that micro-defects have unfavorable effects on the remarkable miniaturization of LSI at the atomic level.

Therefore, first-principles calculations that can simulate the states of atoms in materials are useful to unveil the materials' physical properties. Figure 1 shows a crystal structure model of silicon, which is one of the popular semiconductor materials. After we perform the first-principles calculations with such an arbitrary model as input data, the atomic coordinates are optimized, and the stable structure of the model and the energy are obtained.

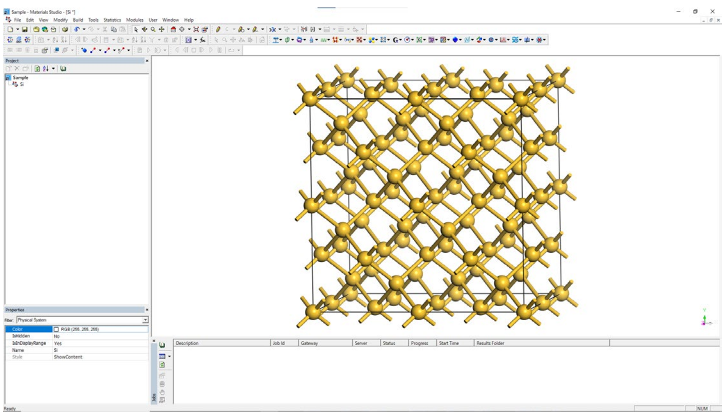

Fig. 1 A crystal structure model of silicon displayed on the general-purpose software (CASTEP).

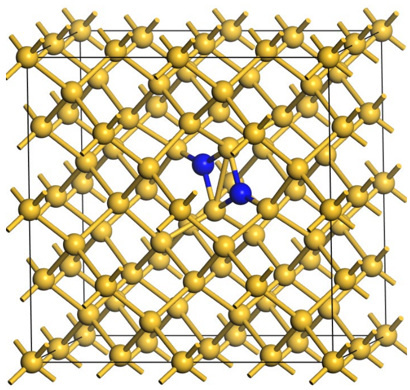

Fig. 2 The stable structure of N-N pair in Si crystal.

Defects in silicon crystals cause performance degradation of semiconductor devices, and defect control is one of the important technical issues in the field of semiconductors. Previous studies of experiments have shown that the size of defects decreases when nitrogen is added to the silicon crystal. However, the mechanism of that phenomenon is not yet understood. In this presentation, we will introduce our study on N-doping in Si crystal. The stable structure of N-N pair is shown in Fig.2. By calculation, we can estimate how the structure changes when a defect is formed around this structure and how the energy changes at that time. Therefore, we are analyzing the phenomena that occur when nitrogen is added to Si crystals by calculation.

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Simulation-based process optimization in the rubber industry - An exemplary use-case from a tire manufacturer

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Introduction

In the age of Industry 4.0, the degree of automation has increased sharply in all areas of production, including plastics and rubber processing [1]. Nowadays, most industrial rubber compounds are manufactured in a discontinuous process in the internal mixer. In order to be able to guarantee consistently high quality, it is necessary to check the individual batches regularly using defined compound-specific parameters in order to identify possible quality fluctuations at an early stage [2]. This, in turn, will benefit multiple economic performance indicators such as production output, rework rates, and wastage. In this context, compound-specific parameters, online monitoring systems are promising tools to ensure a constant control of relevant parameters and optimize operations by automatically adapting production characteristics in favor of efficient process flows [3]. Yet, these systems are not (yet) a common standard in the rubber industry and require large initial investments for setup and operation [2]. Moreover, there is a dearth of insights on the cost-benefit ratio of such solutions when considering complex, multi-layered production processes such as present in the tire manufacturing industry. Currently, research and practice lack comprehensive knowledge on process- and outcome-related implications of online monitoring systems. Accordingly, using the tire industry as representative example, this study asks:

What is the economic impact of an online monitoring system when considering the holistic manufacturing process of a tire manufacturer?

Simulation Model

In order to answer the proposed research question, a computerized simulation model was developed in AnyLogic (v. 8.8.0). In order to reflect the autonomous behavior and interactions of active agents (e.g., workers) within the process-centric operations model, a combined simulation approach featuring discrete-event as well as agent-based simulation techniques has been applied [4]. The simulation model has been informed by the operations of a German tire manufacturer and provides a comprehensive conceptualization of all processes related to inbound storage, rubber mixing, component production, tire mounting, vulcanization, quality control and outbound storage. As depicted in Figure 1, the simulation calculates economic implications based on turnover as well as eight cost indicators, namely human resources, maintenance, energy, material, storage, production, investment, and waste management.

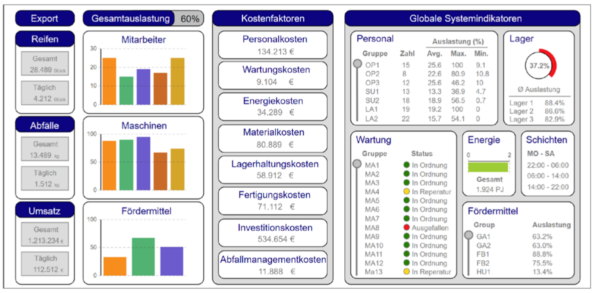

Fig. 1 Simulated economic performance indicators

Preliminary results

Our experiments have shown that the implementation of an online monitoring and control system can be amortized after an operational period of 12 months. After this period, tire manufacturers can annually save up to 8% in human resource costs, 12% in maintenance costs, 7% in energy costs, 22% in material costs, 4% in storage costs, 8% in production costs, and 25 % in waste management costs compared to operations without online monitoring.

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