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Diplomarbeitspräsentation

A Comparative Perceptual Study of Soft Shadow Algorithms

Masterstudium:
Visual Computing

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Motivation

In the field of real-time graphics the simulation of soft shadows is an important research area. On the one hand soft shadows increase realism in virtual environments and on the other hand require a lot of computational effort. Today there is a variety of algorithms that differ a lot in performance and quality. This leads us to the following research questions:

1) How plausible do soft shadows have to be?

2) How can different degrees of user experiences be captured in a study?

The first question is important for developers and researchers to increase performance in real-time applications and to create faster and more plausible algorithms. But to answer this question, different levels of user experience have to be considered that range from inexperienced to experienced users. Hence we have to design a user study that can handle different levels of user experiences.

Contribution

The new experiment design allows us to capture and evaluate different degrees of user experiences without training people beforehand.

The methodology is designed to suit the participants' way of making decisions. Since the design allows participants to make neutral choices, we can pursue the reason for these decisions through our evaluation concept.

Through an experiment we show that approximating contact hardening in soft shadows is sufficient for the average user and not significantly worse for experts.

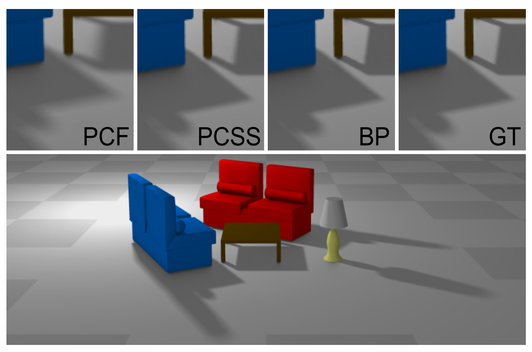
Knowing that contact hardening is the most important feature in soft shadows, we can think of new ways to increase performance and robustness in soft shadow algorithms.

Algorithms and Stimuli

We decided to restrict our survey to four representative soft shadow algorithms, which span the whole range from simple but heuristic, to costly but fully physical.

Percentage Closer Filtering (PCF)
- no contact hardening
- no penumbra size estimation
- fast and robust

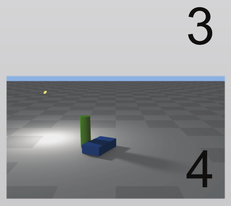
Percentage Closer Soft Shadows (PCSS)
- contact hardening
- penumbra size estimation
- fast but light bleeding artifacts



Backprojection (BP)
- contact hardening
- accurate penumbra size estimation
- overshadowing artifacts

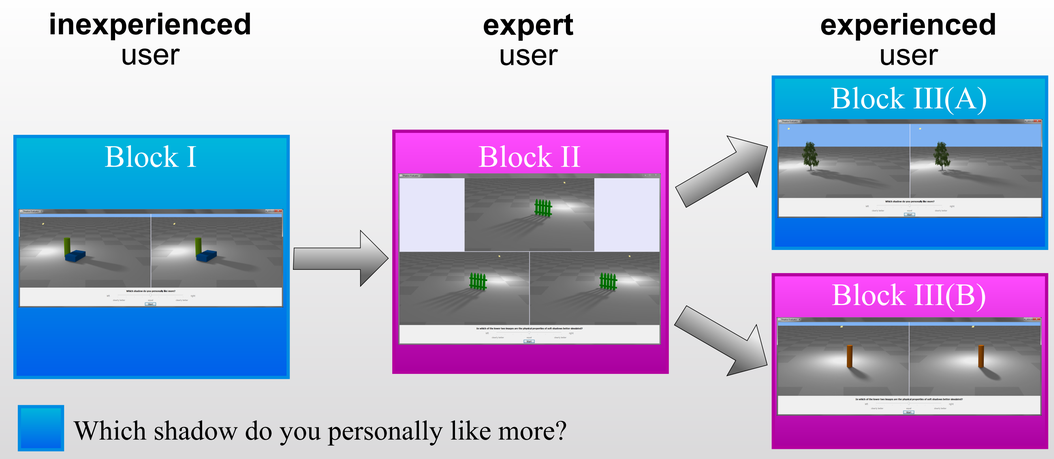
Ground Truth (GT)
- reference solution created by accumulating 1024 point lights
- fully physical

The stimuli in the empirical experiment are 3D scenes that we assigned to 13 categories. We found out that two dimensions contribute to the complexity of soft shadows: First, the complexity of objects and second, the complexity of penumbras.

	simple, regular objects	complex, known objects		game scene
consistent penumbra	1	5		 13
varying penumbra	2	6	repeated objects	organic, random objects
consistent, overlapping penumbra	3	7	9	11
varying, overlapping penumbra	 4	8	10	12

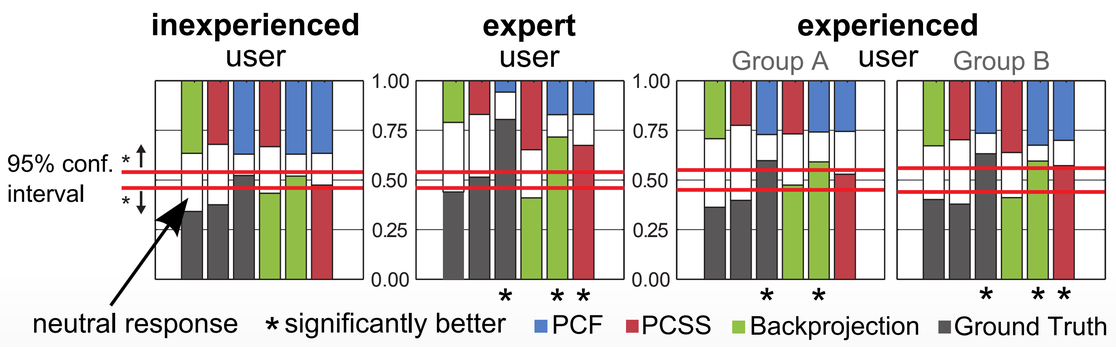
Experiment Design

To simulate different levels of user experiences, we introduce a novel block design concept that reuses knowledge participants gain during the study. In the first block participants are *inexperienced* which is similar to other studies. In the second block participants see the reference solution (which makes them *experts*) and have to compare the other algorithms to it. This has a learning effect on participants and they become *experienced* users in the third block.

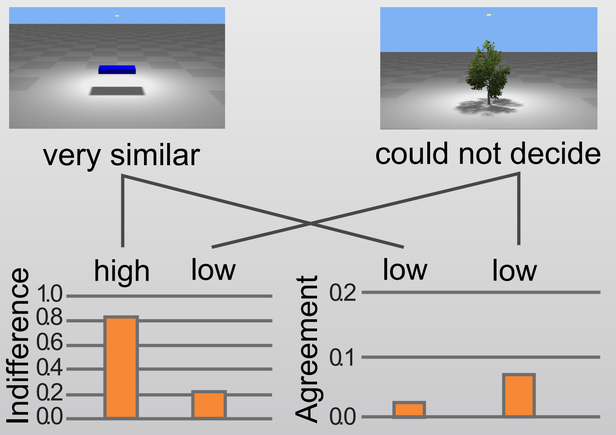


In contrast to other studies, participants are not forced to decide between two images if they look alike. Instead we offer a neutral choice that enables us to pursue the reason for participants' decisions.

Results



As we can see, only PCF is outperformed by other algorithms. It is the only algorithm that does not approximate contact hardening in soft shadows. PCSS, the next best algorithm in terms of plausibility, is already good enough so none of the others is significantly better. Hence we conclude that simulating contact hardening in soft shadows is sufficient for the average user and not significantly worse for experts.



By allowing neutral responses, we can compute a coefficient of indifference which, in combination with Kendall's coefficient of agreement [1], enables us to identify categories where algorithms produce *very similar* results and categories where participants saw differences, but *could not decide* if they are errors or not.

Conclusions

We introduced a new experiment design that captures inexperienced, experienced, and expert users by reusing knowledge participants gain during a study.
Moreover, we were able to show that approximating contact hardening in soft shadows is sufficient for the average user.
In future work we want to incorporate animation of the camera, light source, and scene objects and other parameters, like high-frequency noise and textures.

References

[1] Maurice Kendall and Jean D. Gibbons. Rank Correlation Methods. A Charles Griffin Title, 5 edition, September 1990.

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