Fast Reactive Control for Illumination Through Rain

Raoul De Charette[1], Robert Tamburo[2], Pete Barnum[3], Takeo Kanade[2], Anthony Rowe[2], Srinivas Narasimhan[2]

[1]Mines ParisTech, [2]Carnegie Mellon University, [3]Texas Instruments

Objective

The integration of image sensors and light sources is typically limited to high-latency computing systems. We seek to develop a high-speed system capable of performing image analysis in coordination with reactive control of imaging and illumination.

Application

Problem: Visibility while driving at night is dramatically reduced during precipitation (Fig. 1). *Can we make rain invisible?*

Approach: Using low-cost, off-the-shelf components, control a light source to deactivate light rays that intersect rain drops (Fig. 2).

Goals: Demonstrate feasibility of approach by computer simulation and a prototype system.

Fig. 1: Illuminated rain drops.

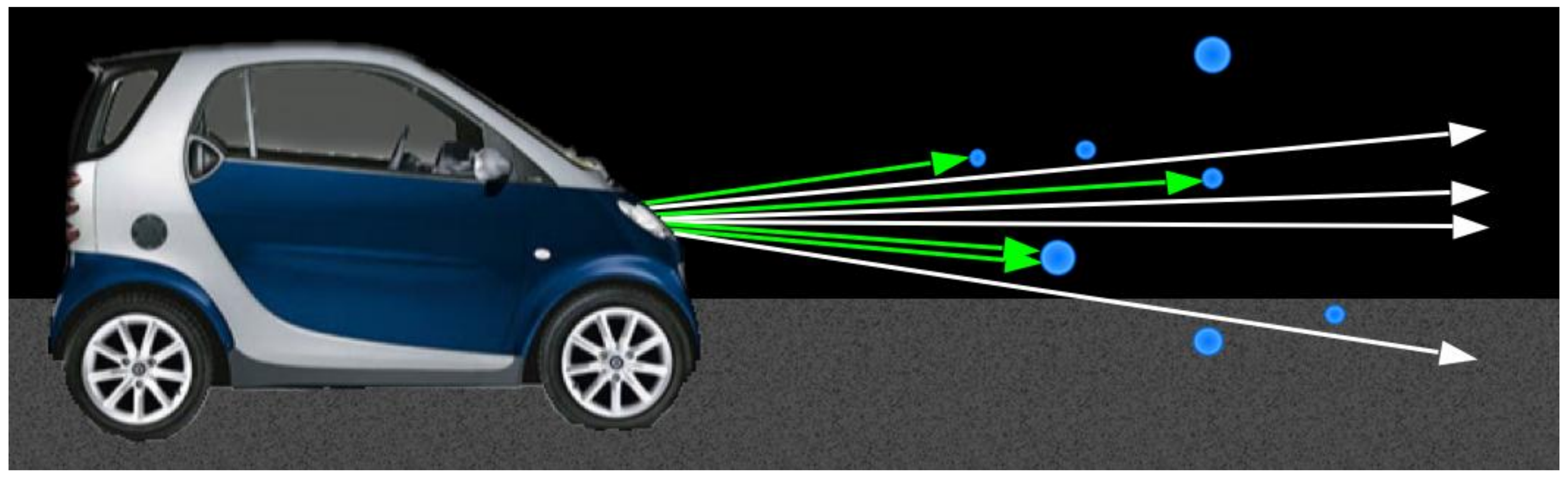


Fig. 2: Deactivation of light rays intersecting rain drops.

Methods

System: An optically co-located camera and projector, images and illuminates rain drops (Fig. 3). Drops are detected, their future locations predicted, and intersecting rays deactivated.

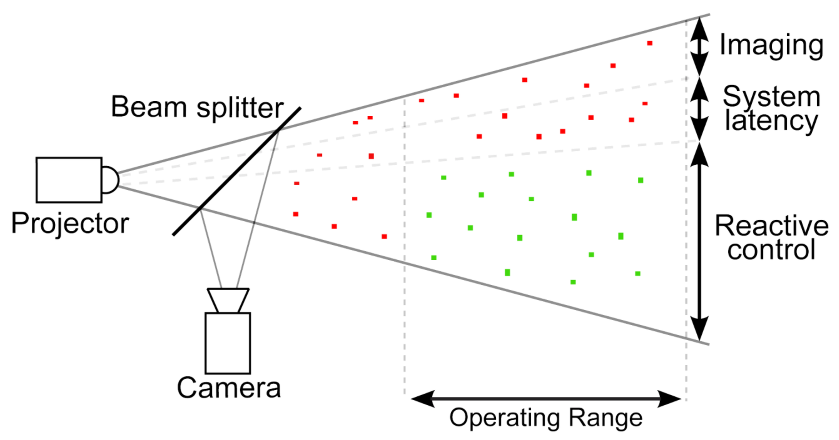


Fig. 3: Camera-projector system.

Simulation: Parameters of system simulated to evaluate *accuracy* and *light throughput*. (Fig. 4).

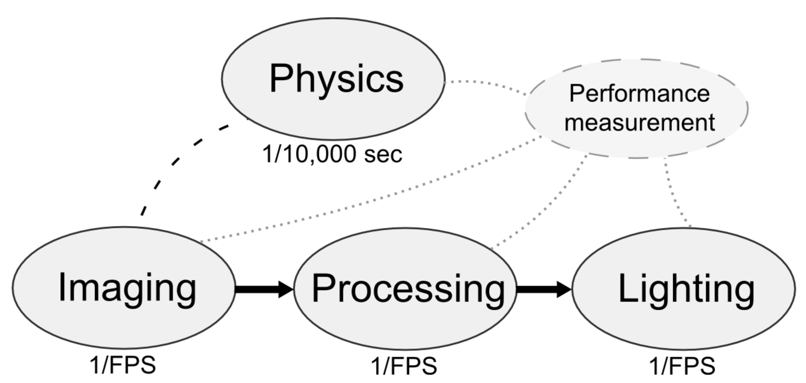
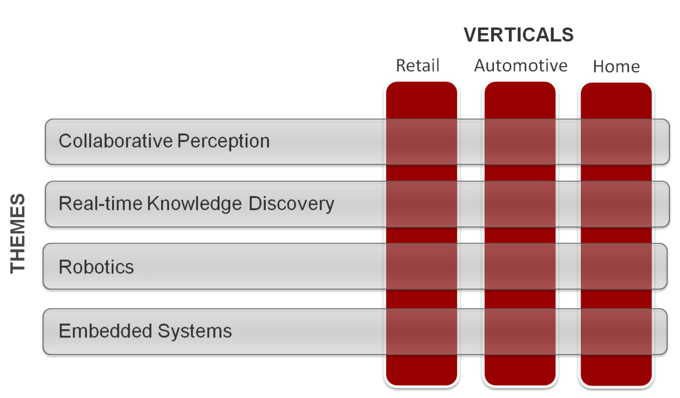


Fig. 4: Simulator components.



Results

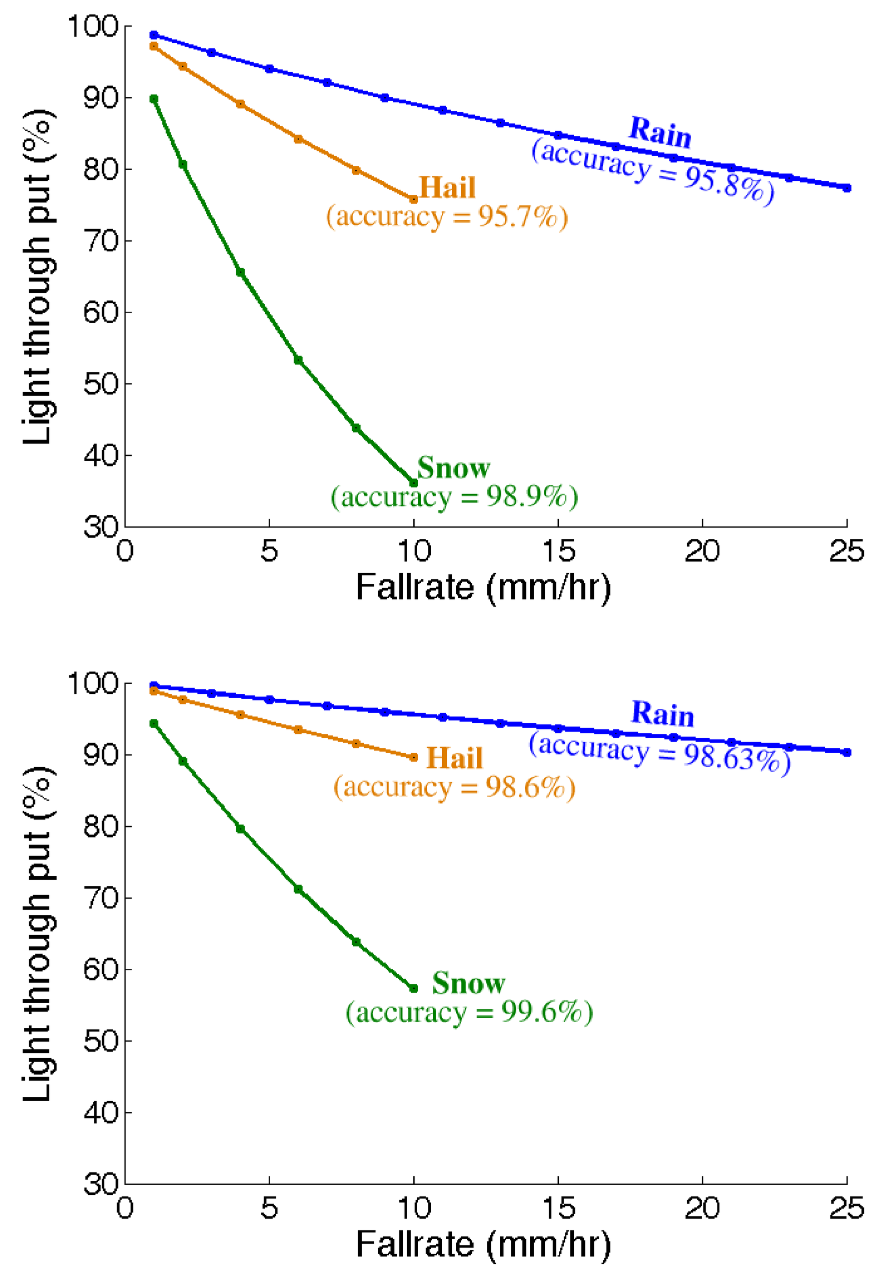


Fig. 5: Simulation results for light throughput. Top shows results for simulated prototype system. Bottom shows results of futuristic system.

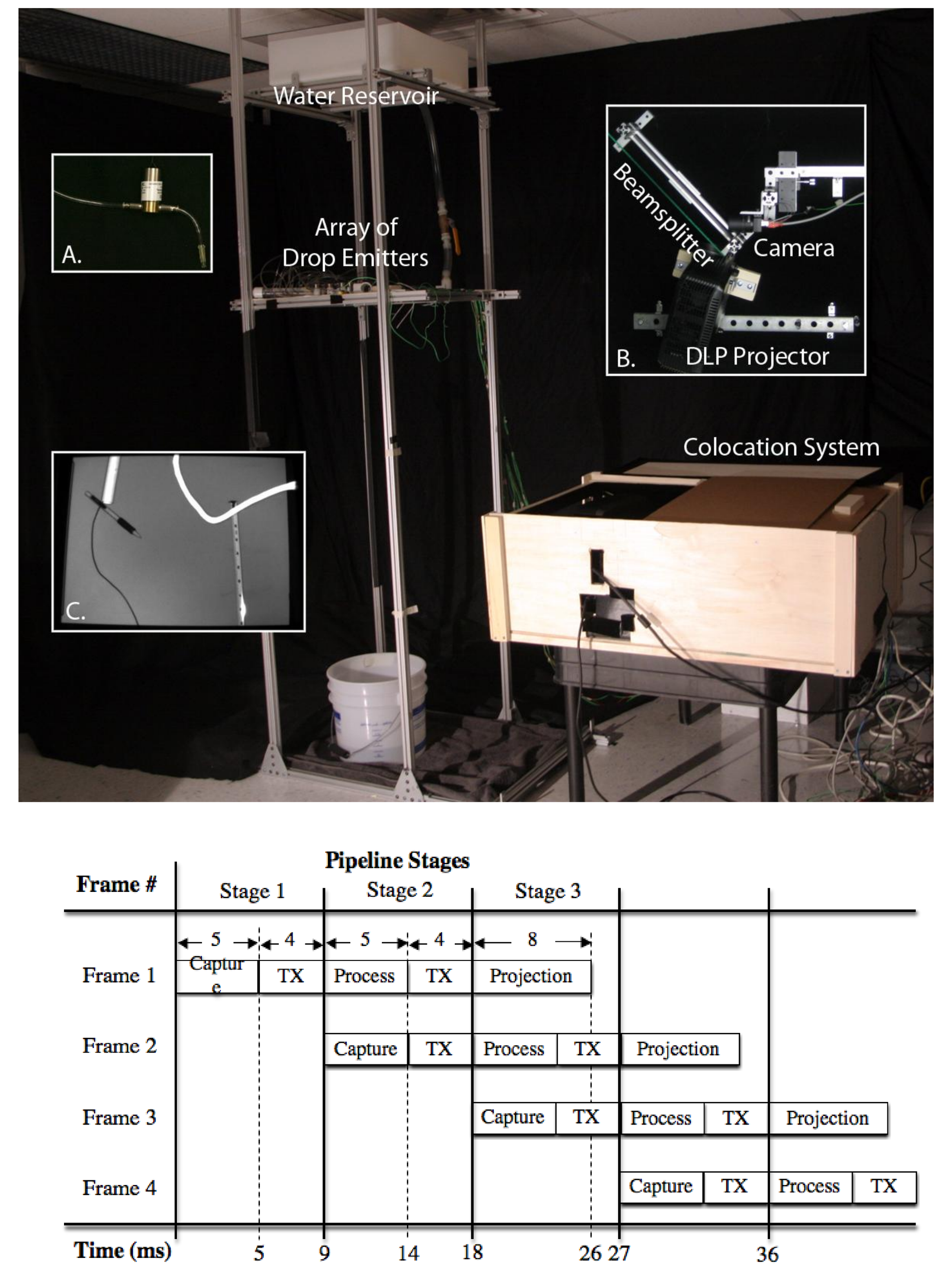


Fig. 6: Top shows experimental setup (computer not pictured). Bottom shows processing pipeline. System latency is 13 ms.

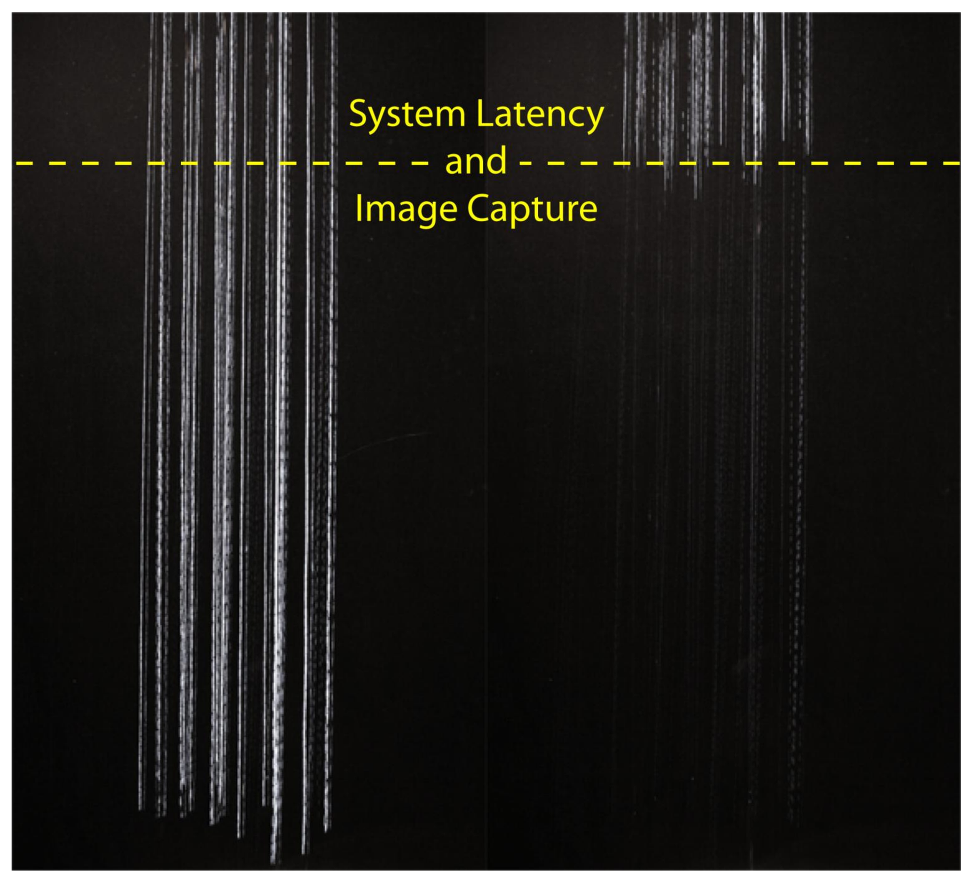


Fig. 7: System at 120 Hz. Left shows all drops illuminated. Right shows adaptive illumination (97% light throughput).

Fig. 8: Results for system at 120 Hz against cluttered background. Left/right shows full/adaptive illumination.

Conclusions

Computer simulations and a prototype system demonstrate our approach to adaptive lighting is feasible. The main system bottlenecks are image transfer, analysis, and memory management. If these challenges can be overcome, the system can be used for numerous real-time applications. Acknowledgements: NSF, ONR, and Intel ISTC