Technische Universität Berlin

EINSTEIN CENTER Digital Future

Event-based Robot Vision

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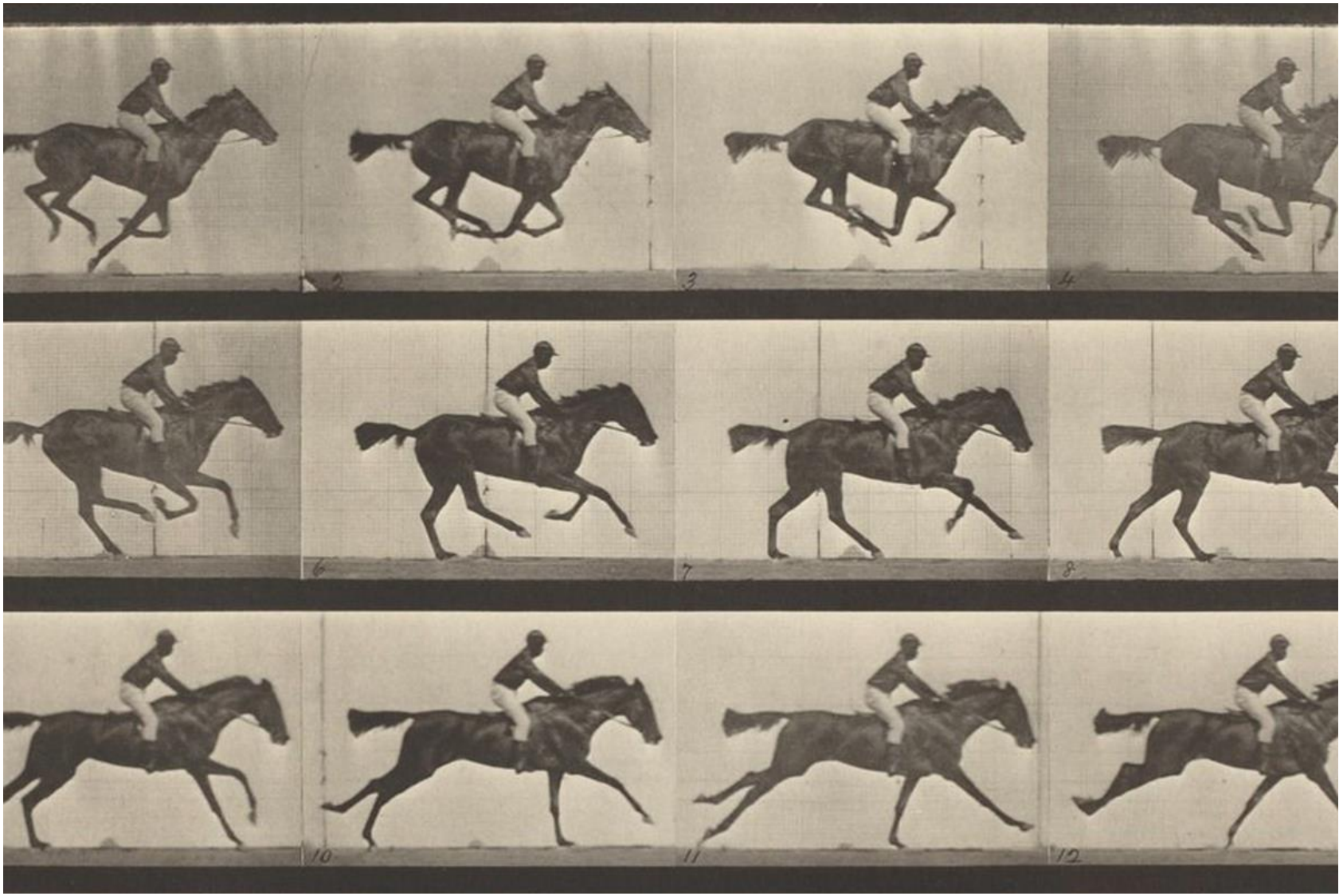
How do we capture visual information?



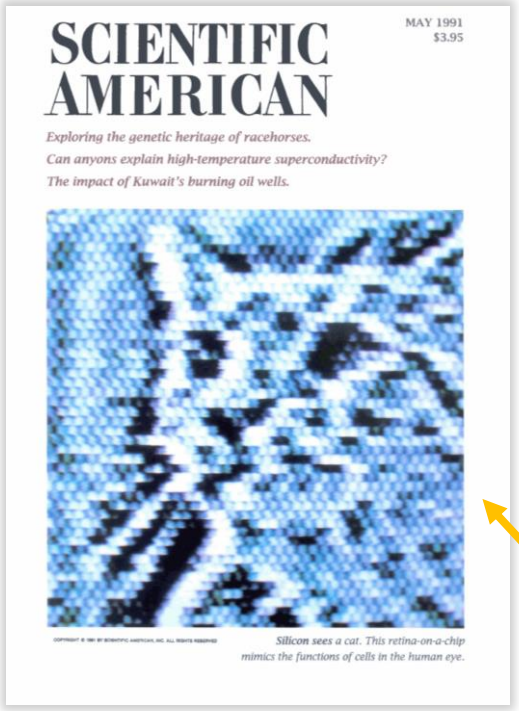
Master of Photography E. Muybridge ca. 1878. "*The Horse in Motion*"

How do we capture visual information?

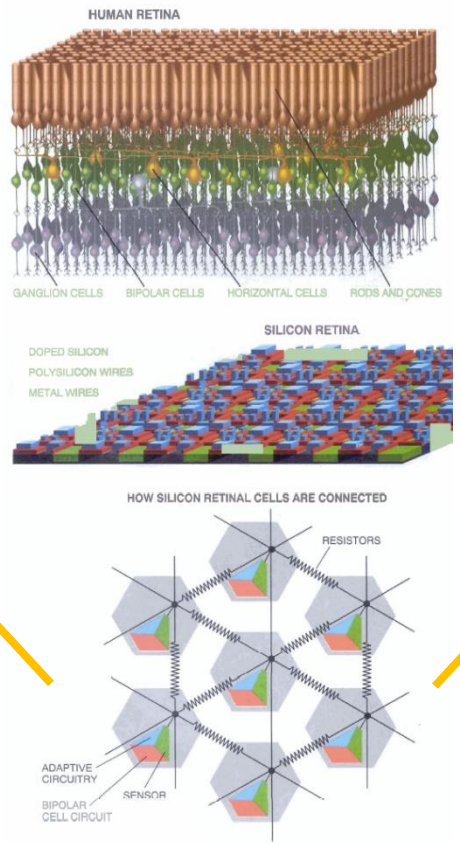
What is Motion - Eadweard Muybridge (1878) https://youtu.be/6XGEq37Dnso

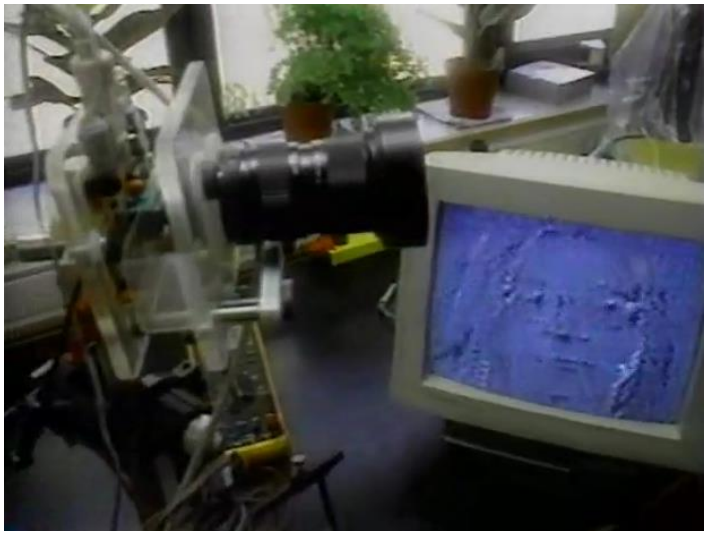
M. Mahowald & C. Mead (~1990)

- The spark of “Neuromorphic Engineering”
- Bringing **biology** into chip design on silicon (**engineering**)



Modeling Neural Structures in Silicon





Retina-on-a-chip demonstration

Silicon Vision - Misha Mahowald https://www.dailymotion.com/video/x28ktma

Two types of cameras important to us (~2014)

Standard, frame-based camera
(outputs images
Here, frame rate= 6 Hz)

vs

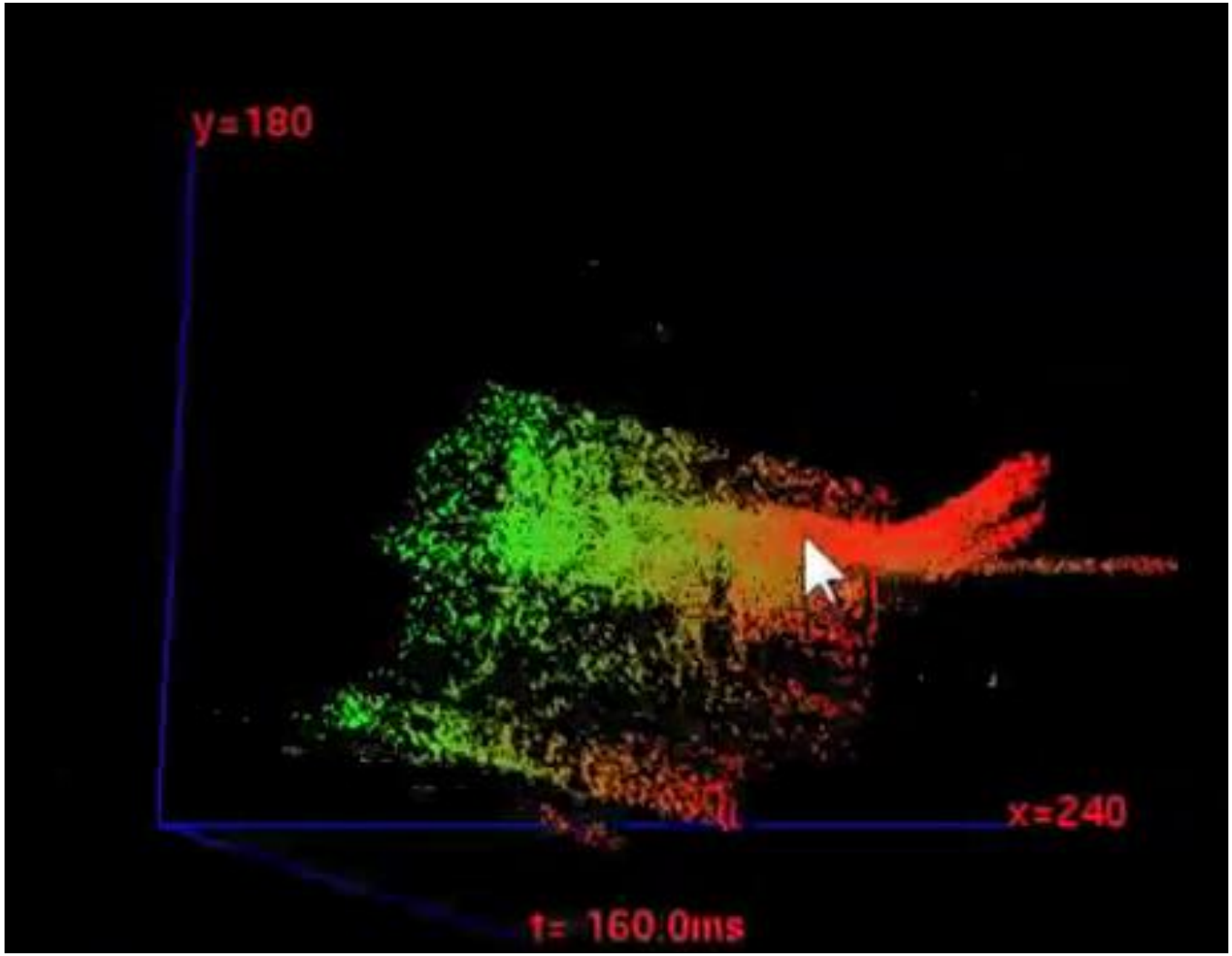
Event-based camera
(outputs "events" or "spikes", represented as red and green dots in the video)

Video: camera inventor Tobi Delbruck playing tennis https://youtu.be/Fikd4Ee9d-s

Space-time visualization of events

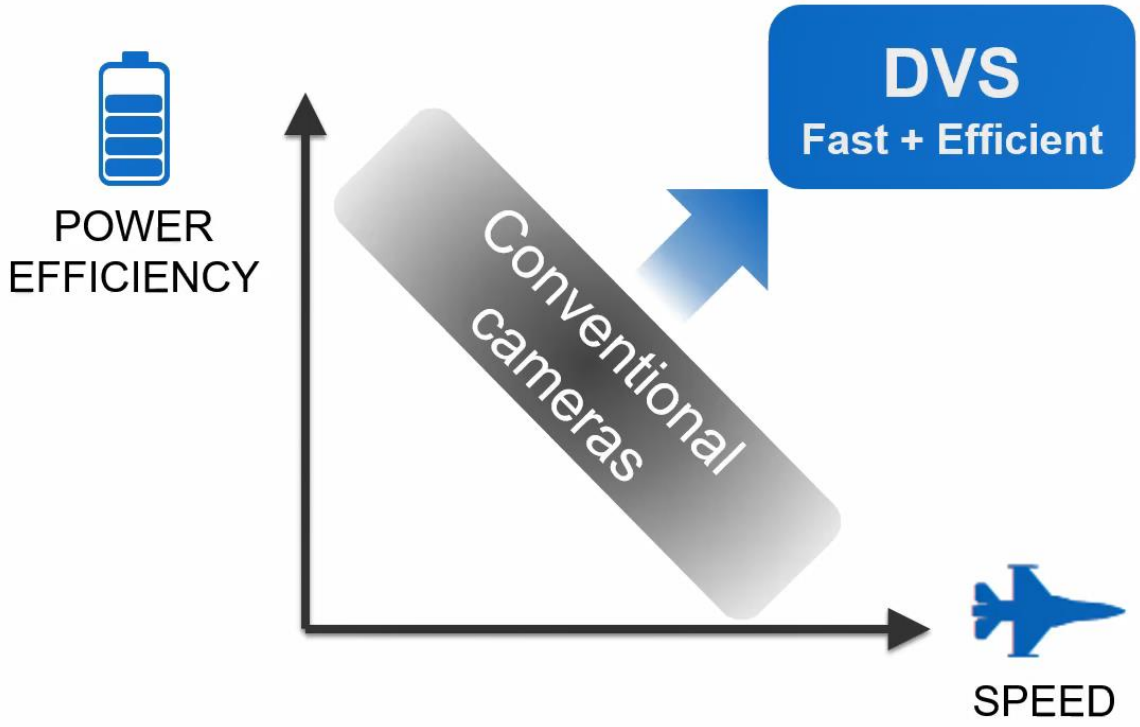
Space: sensor size is 240 x 180 pixels
Time: 160 ms

In the video, time is colored: red means new, green means old (look at the trajectory of the tennis ball).



Video: tennis player, space-time view https://youtu.be/bqhUQ7QV5gQ

Event camera. Efficiency - Latency trade off

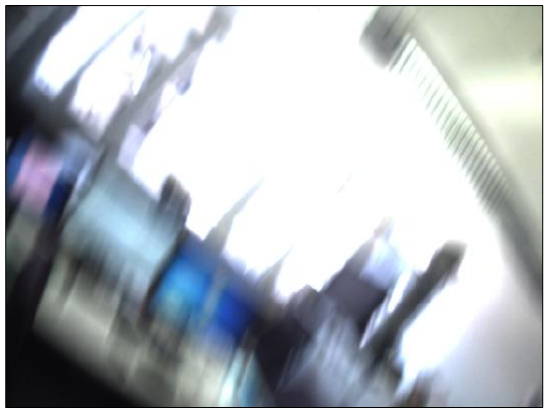


The DVS beats the power vs speed trade-off providing high speed at low power.

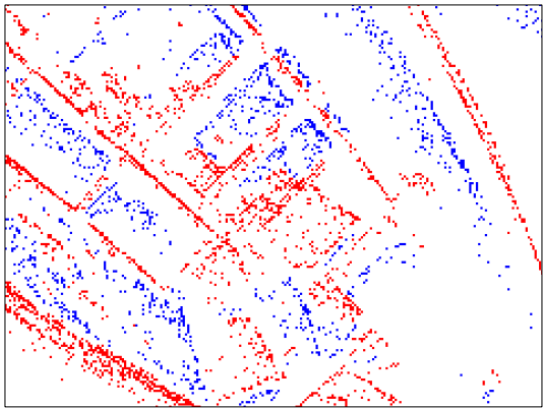
Video by iniVation https://www.facebook.com/inivation/videos/176121543038362/

Comparison of two camera types

> 60 years of research!



< 10 years research



	Standard Camera	**Event Camera**
Update rate	Low (synchronous)	High (asynchronous): 1 MHz
Dynamic Range	Low (60 dB)	High (140 dB)
Motion Blur	Yes	Almost none
Absolute intensity	Yes	No (but it can be reconstructed)
Mature?	Yes	Not yet

Courtesy of D. Gehrig, ECCV 2018

References

Reading:

- Mead & Mahowald. *The Silicon Retina*, Scientific American 1991.
- If curious, read about early motion studies and devices:
  https://en.wikipedia.org/wiki/Eadweard_Muybridge#1872-1879:_Stanford_and_horse_gaits
  https://en.wikipedia.org/wiki/Eadweard_Muybridge#Later_motion_studies
- T. Delbruck, *The Slow but Steady Rise of the Event Camera*, EE Times 2020.

Videos:

- Silicon Vision - Misha Mahowald https://www.dailymotion.com/video/x28ktma
- E. Muybridge BBC documentary https://youtu.be/5Awo-P3t4Ho