Georgia Institute of Technology


# Computational Photography

**Dr. Irfan Essa**
Professor
School of Interactive Computing

Study the basics of computation and its impact on the entire workflow of photography, from capturing, manipulating and collaborating on, and sharing photographs.


# Digital Video

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Video is basically just a stack of images in Time.

# Lesson Objectives

- ★ Explain in your own words, the relationship between Images and Videos.
- ★ Describe in your own words the importance of persistence of vision in playing (and capturing) Videos.
- ★ Describe in your own words how we can extend filtering and processing of Images to Videos.
- ★ Describe the two (2) methods used for tracking points in Videos.

# REVIEW: A Digital Image

Georgia Tech's Mascot Buzz

- "Digital" Image:
  - numeric representation in two-dimensions (*x* and *y*)
  - referred to as *I(x,y)* in continuous function form, *I (i,j)* in discrete
- Image Resolution:
  - expressed as representation of Width and Height of the image.
- Each pixel (picture element) contains light intensities for each value of *x* and *y* of *I(x,y)*.

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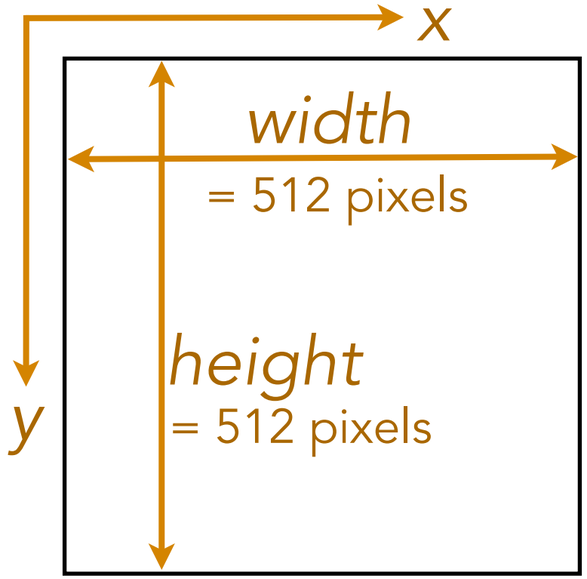
# REVIEW: A Digital Image

Georgia Tech's Mascot Buzz, in Black and White




512x512 pixels
= 262,144 pixels
= .26 MP image

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# Video: Images OVER time

- ★ "Digital" Video:
  - numeric representation in two-dimensions (*x* and *y*), stacked in time, *t*
  - referred to as *I(x,y, t)* in continuous function form, *I (i,j,t)* in discrete
- ★ Video Resolution:
  - expressed as representation of Width and Height of the image.
  - Usually in aspect ratios of 4x3, 16x9, etc.
- ★ File formats: Include images, frame-rates, and codec/wrappers

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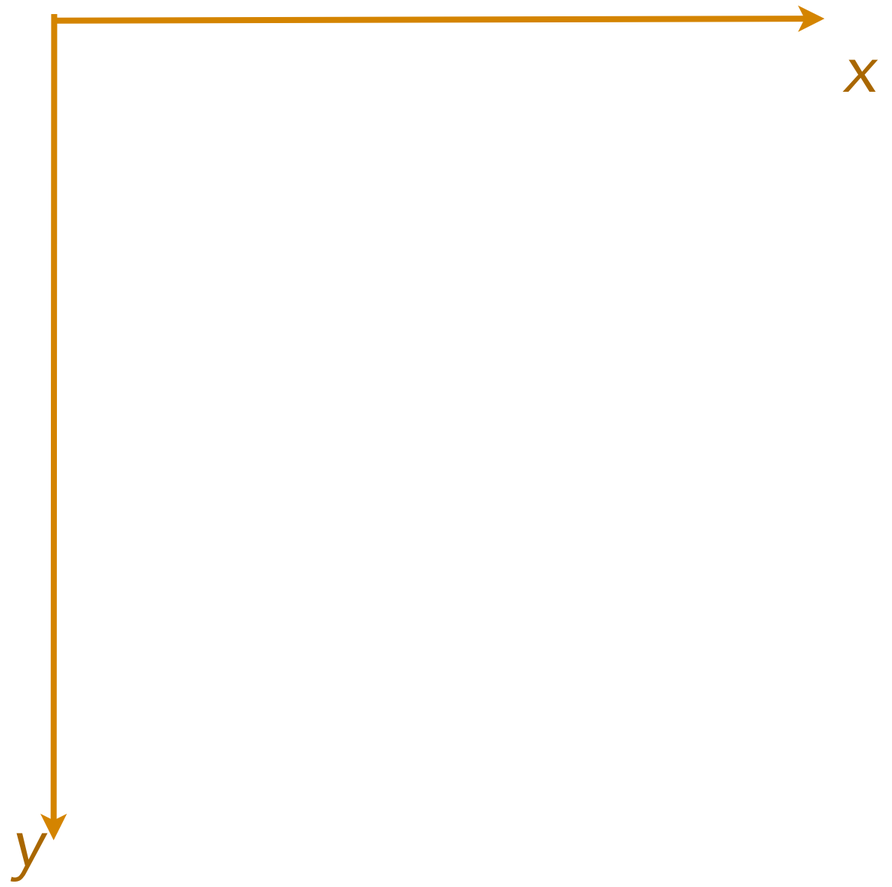


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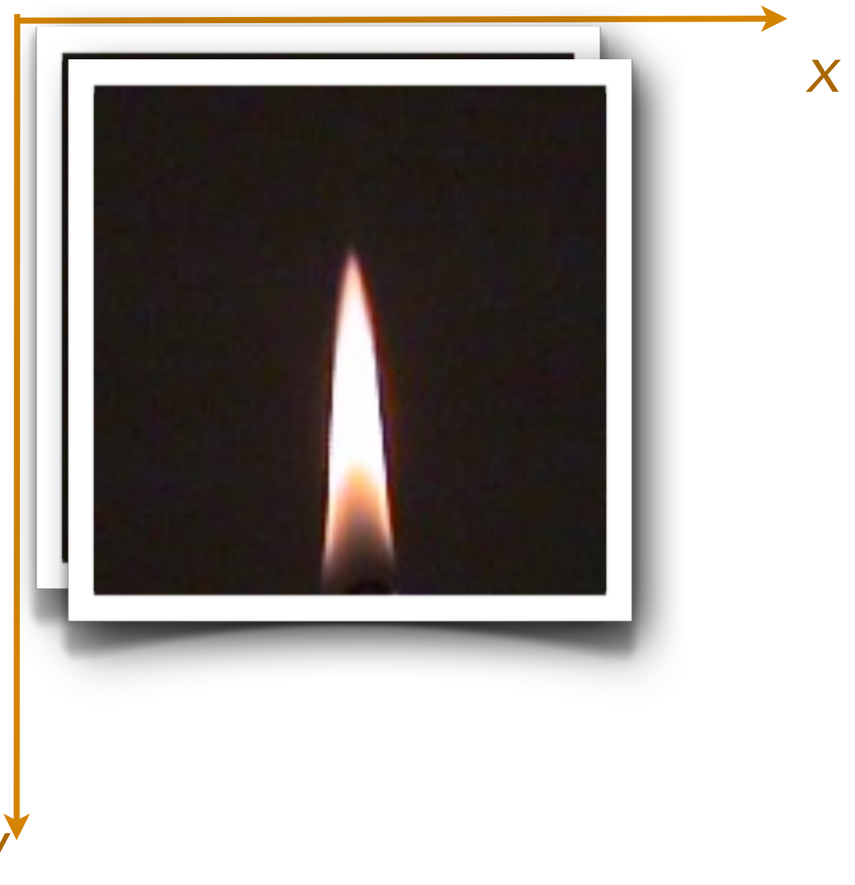


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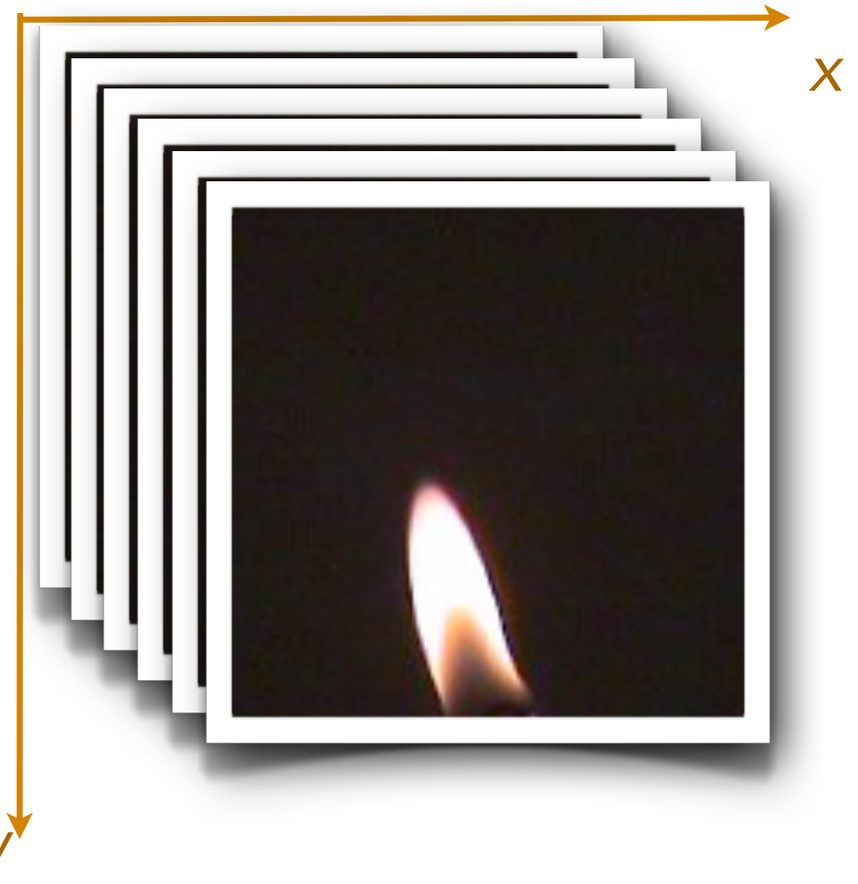


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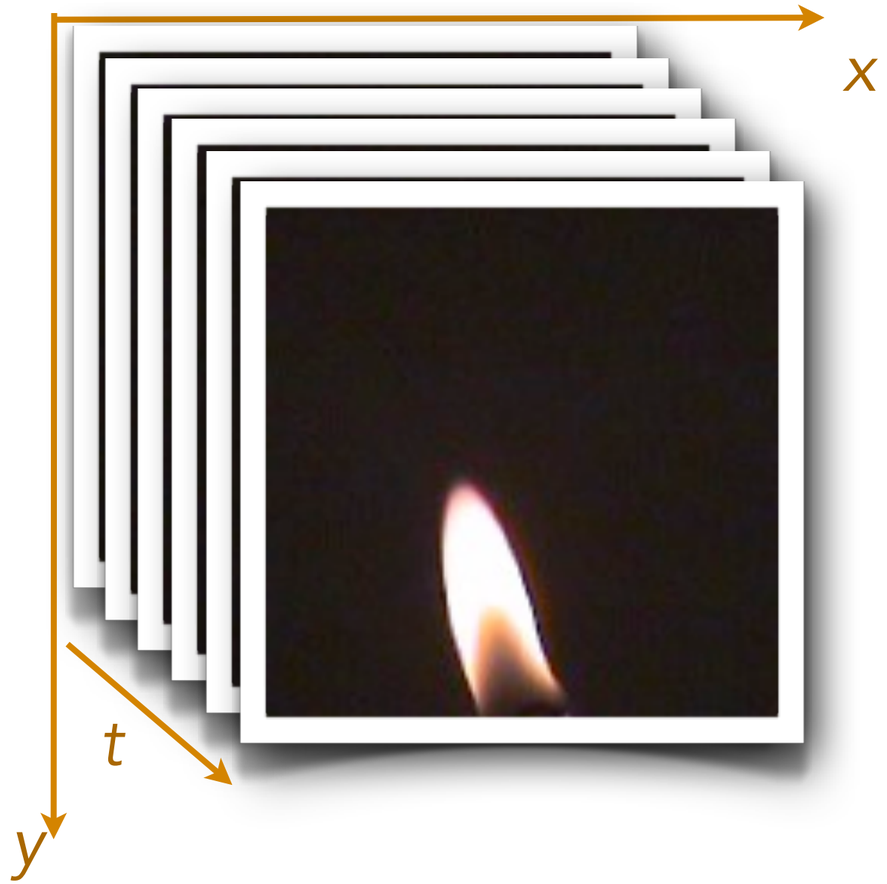


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# "Persistence of Vision"

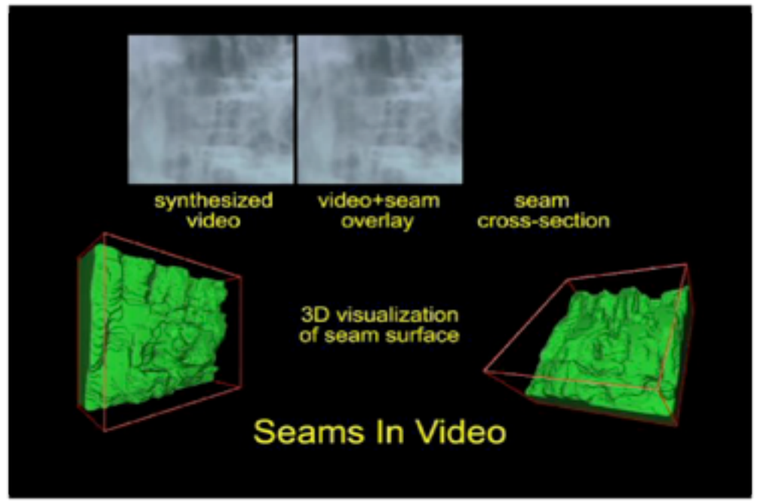
- If image frames are captured and then are played back (refreshed) at a rate faster 1/24th of a second, then we see continuous appearance of motion and no flicker.
- This is a foundational observation of why we perceive video.
- Also, the rationale behind invention of video cameras.
- Muybridge (1830-1904) used stop-action photographs to study animal motion
- Marey (1830-1904) developed Chronophotographe to capture motion.

en.wikipedia.org/wiki/File:Muybridge_race_horse_animated.gif
Pictured in 1887, Animated in 2006

http://en.wikipedia.org/wiki/File:Marey_-_birds.jpg

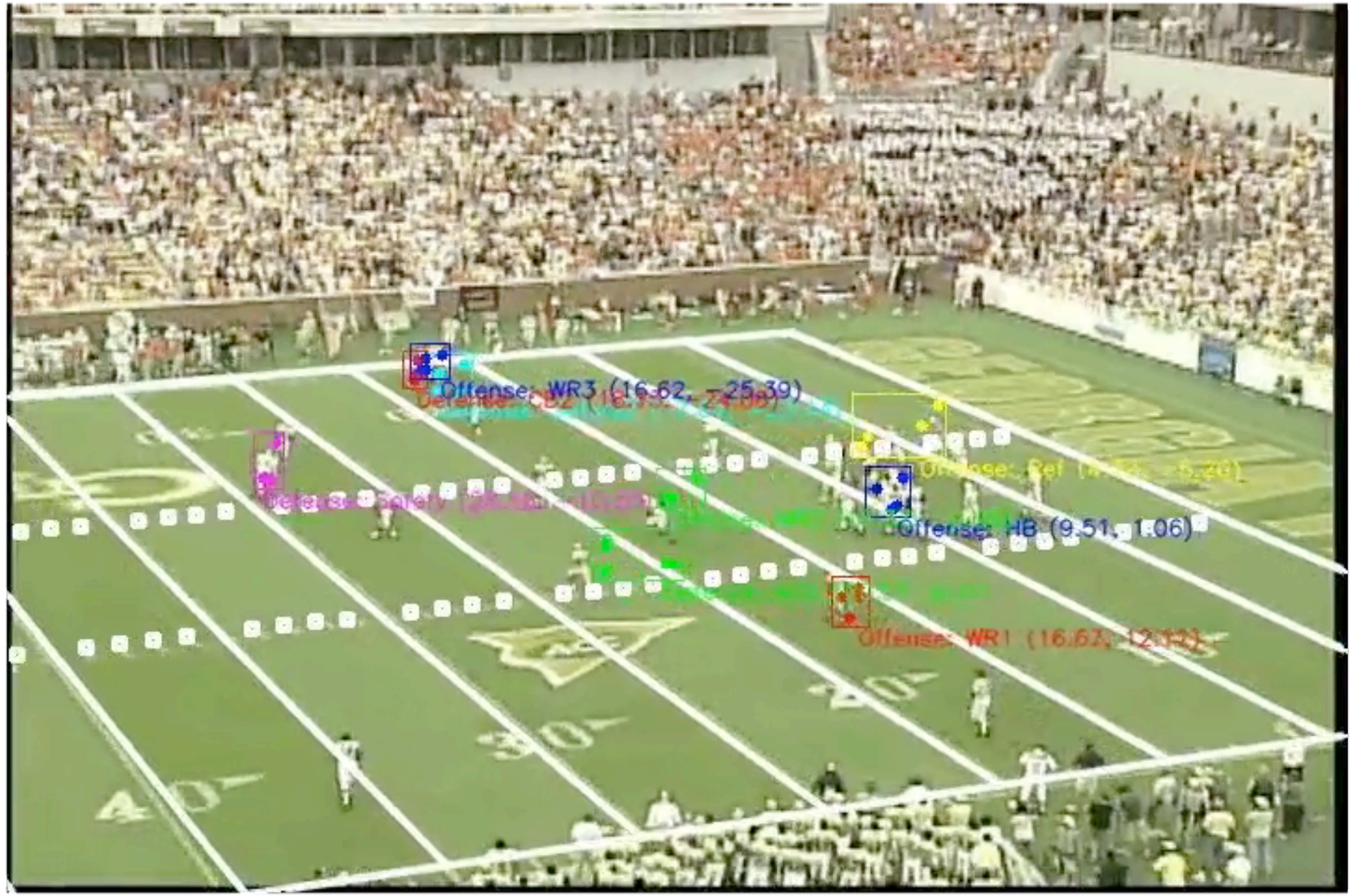
# Processing/Filtering Video

- ★ Same as with images, just over a video volume
- ★ Can filter in 3D (*x*, *y*, *t*)
- ★ Same concepts of change detection as we did in *xy*-space can apply to *xt*- and *yt*- space.
  - e.g., if all pixels from one frame to another frame, that follows, it are different, than it maybe a drastic motion change (a camera move) OR a scene cut (due to edit).
- ★ Motion information is used in video compression.



# Feature Detection, Matching, and Tracking

- ★ Again, same as in images
- ★ However, can leverage the fact that features found in one frame may be visible in the next.
- ★ Can take direct approaches to tracking (find a feature, and match it to feature in the next frame), OR
- ★ Pure motion-based approaches, where compute the motion at pixel level between frames (referred to as OPTICAL flow) and then find objects/ features in the image.




# Tracking, Registration in Video

(Hecht, Kazian, Mansour, St. John, Stallworth, Essa 07)

# Registration and Blending in Video

(Kim, Oh, Essa 2009, 2012)

# Summary

- ★ Discussed the representational relationship between Images and Videos.
- ★ Introduced the concept of persistence of vision in playing (and capturing) Videos.
- ★ Discussed the extension of filtering and processing from Images to Videos.
- ★ Described two methods used for tracking points in Videos.

https://commons.wikimedia.org

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# Next Class

★ Video Textures and More ...

# Credits

- ★ For more information, see
  - Richard Szeliski (2010) Computer Vision: Algorithms and Applications, Springer.
- ★ Some video retrieved from
  - http://commons.wikimedia.org/.
  - From Professors Essa's Lab.
  - List will be available on website.

www.flickr.com/photos/neneonline/231886965/




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