Do I need a title? ‘How to capture our reality’

Hold bottle and laser? Tomato? (Femto-videography)

How to get claps after a video?

Use space| stay in one location

My passion is to create new imaging platforms that have a super human visual ability .. With cameras that can see the unseen ..

2. Doc Edgerton inspired us with awe and curiosity by with a visualization of a bullet piercing thru an apple using a camera shutter open only for a millionth of a second (Edgerton is equally recognized for his visual aesthetic: many of the striking images he created in illuminating phenomena that occurred too fast for the naked eye) (the man who made time stand still.)

3. Now 50 years later, I present you with a new type of photography.. Femto photography

Where we can visualize (the world) not a mil, bil but trillion frames per second

An imaging technique (virtual slow motion) so fast that we can creates videos of light in motion,

And watching light energy propagate like **ripples of waves** after throwing a stone in the pond of water

4. If I turn this laser point ON and OFF in a trillionth of a second .. i.e. in a few femto-second ..

I will create a burst of photons, less than a millimeter long .. (pulse)

Photons are particles of light traveling at the speed of .. Light

a bullets of LIGHT moving at speed of light .. but nearly a million times faster than an ordinary bullet

5. What if we send this bullet of light into the bottle ..

Can we see the bullet SHATTER inside this bottle ?

Watch this movie with a trillion frames per second imaging

6. There is a lot going on this movie .. So lets break this down .. Pulse .. Scatters inside the bottle .. Hits cap .. Pocket of air .. Energy fronts on the table .. Reflection after several picoseconds ..

In each frame .. Photons are traveling less than a milimeter

Watching an ordinary bullet slowed down as I am showing here .. Will take 3 years to cross the screen .. Watching that ordinary bullet will be an extremely boring movie ..

And no .. coca cola did not sponsor this research

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What about some still life photography

Btw this is how nature PAINTS a photo in time, one femto-frame at a time .. Just a summation of these femto-frames creates the final photo.

Imagine if you have this in your phone few years from now. You will be able to go to your supermarket and tell if that fruit is ripe.

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So how did we build this imaging technique .. my team at MIT Media lab has Microwave sized device.

painstakingly put together a collection of hardware in unexpected ways .. starting w a so called streak tube, new optical tricks, synchronization and computational technique to weave together video from raw data.

And short exposure remember you really don’t get any light, so at one trillionth of a second ..

so we have to use a stroboscopic sampling method to fire the bullet millions of times and do clever sync and record raw data, and use computational techniques to to weave together femto-video.

So we are not capturing fate of a single photon.

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But we can create some other super human abilities .. Maybe for a future super-hero ..

A camera that can look around corners ..

The idea is to use echoes of light .. Multiple bounces ..

We send flash light with our femto-camera to the door, part of it scatters into the room

 A small fraction comes back to the door and even tinier fraction comes back to our femto-camera

By analyzing these multiply bounced photos with trillion frames per second imaging, it turns out we can look around corners beyond the line of sight

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Not just science fiction but we have actually shown this in our lab on a tabletop setup

The camera is on the left and the mannequin is hidden behind the wall .. so how do we do it?

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In the end what kind of quality can we reconstruct

Here is our blobby man with full 3D shape recovered

We have a long way to go before we take this out on the road .. but in the future

We can avoid collision with what is around the bend .. can we proclaim that in 20 years there will be no car accidents?

Or look for survivors in hazardous conditions by sending light and looking for any changes in reflected signal

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What about health .. remember the tomato .. we can effectively do ultrasound w light to see under the screen not by applying funny gel, but with distant observation .. Maybe I can take your femto-photo and figure out skin hydration

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And to see deep inside the body with endoscopes that look in narrow channels in lungs

Or colons

Or heart .. offcourse many challenges due to tissue and blood .. but this is call to scientists to solve the next generation of imaging problems with femto-photography

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And just like Doc Edgerton, a scientist himself .. The science turned into art .. Art of ultra-fast photography ..

I realized .. what we have in not just data for scientific investigation ..

We need a new form of computational photography to visualize this huge amount of data

How about a time lapse where time between photos is only a few trillionth of a second .. each time slot rendered with a rainbow color code ..

Like ripples you see after throwing a stone in a pond of water

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But there is also something funny going on here .. the ripple are moving away from the camera towards the cap of the bottle when we know that light should be moving from cap to the camera?

Well Einstein would have loved to see this femto-photo

It turns out that because we are recording nearly at the speed of light, there is reversal in how we observe events in the world. After a correct mathematical space-time warp, we can correct for this time distortion.

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So whether it is looking at light in motion, seeing around corners, or create next generation of health diagnostics, femto-photography shows us there is more light to shed at the end of the tunnel.

We cannt just say let there be light .. let there be a femto-camera

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Need to explain how camera works (streak tube mention)

Go download datasets at femtophoto.org, suggest collaborations and your configurations

Ack all femto authors on various slides, esp Di and Chris

1 sec of movie, is 1 Terabyte of \* 1M = 1 Petabyte, and would req 300 years