Motion Magnification

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증강지능연구실 황승현

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제목:

Eulerian Video Magnification for Revealing Subtle Changes in the World

저자:

Hao-Yu Wu et al. / MIT CSAIL

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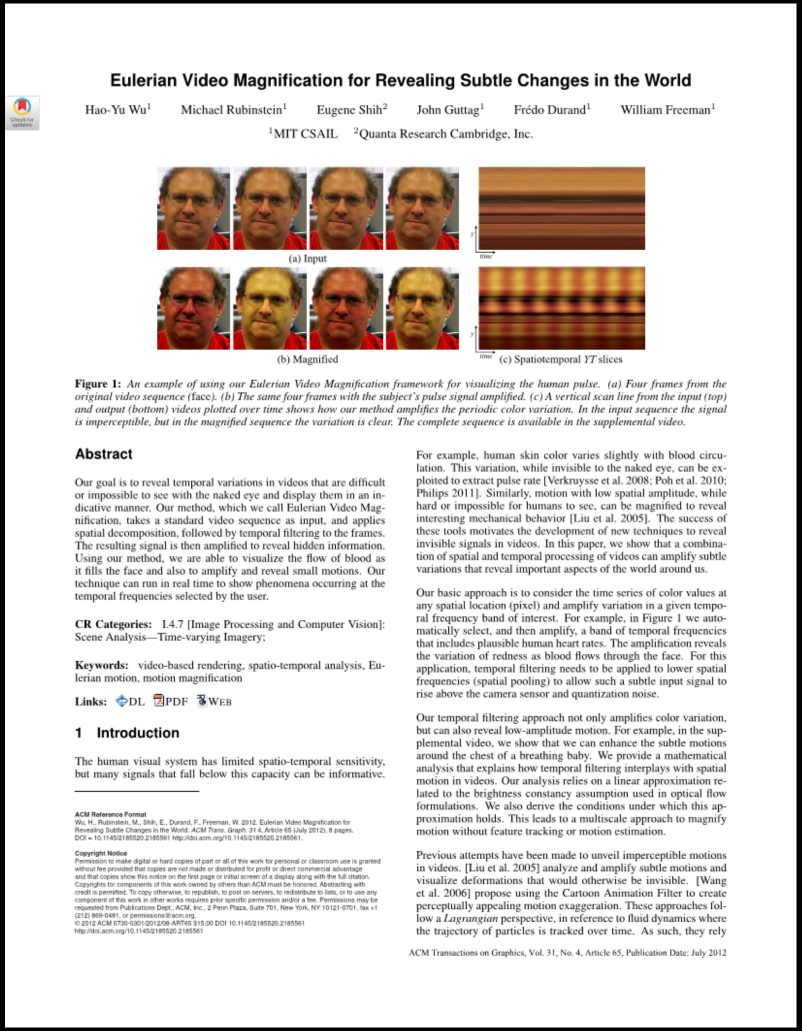
ACM Trans. Graph.



Eulerian Video Magnification for Revealing Subtle Changes in the World

Hao-Yu Wu[1] Michael Rubinstein[1] Eugene Shih[2] John Guttag[1] Frédo Durand[1] William Freeman[1]

[1]MIT CSAIL [2]Quanta Research Cambridge, Inc.

(a) Input

(b) Magnified

(c) Spatiotemporal *YT* slices

Figure 1: *An example of using our Eulerian Video Magnification framework for visualizing the human pulse. (a) Four frames from the original video sequence* (face)*. (b) The same four frames with the subject's pulse signal amplified. (c) A vertical scan line from the input (top) and output (bottom) videos plotted over time shows how our method amplifies the periodic color variation. In the input sequence the signal is imperceptible, but in the magnified sequence the variation is clear. The complete sequence is available in the supplemental video.*

Abstract

Our goal is to reveal temporal variations in videos that are difficult or impossible to see with the naked eye and display them in an indicative manner. Our method, which we call Eulerian Video Magnification, takes a standard video sequence as input, and applies spatial decomposition, followed by temporal filtering to the frames. The resulting signal is then amplified to reveal hidden information. Using our method, we are able to visualize the flow of blood as it fills the face and also to amplify and reveal small motions. Our technique can run in real time to show phenomena occurring at the temporal frequencies selected by the user.

CR Categories: I.4.7 [Image Processing and Computer Vision]: Scene Analysis—Time-varying Imagery;

Keywords: video-based rendering, spatio-temporal analysis, Eulerian motion, motion magnification

Links: DL PDF WEB

1 Introduction

The human visual system has limited spatio-temporal sensitivity, but many signals that fall below this capacity can be informative. For example, human skin color varies slightly with blood circulation. This variation, while invisible to the naked eye, can be exploited to extract pulse rate [Verkruysse et al. 2008; Poh et al. 2010; Philips 2011]. Similarly, motion with low spatial amplitude, while hard or impossible for humans to see, can be magnified to reveal interesting mechanical behavior [Liu et al. 2005]. The success of these tools motivates the development of new techniques to reveal invisible signals in videos. In this paper, we show that a combination of spatial and temporal processing of videos can amplify subtle variations that reveal important aspects of the world around us.

Our basic approach is to consider the time series of color values at any spatial location (pixel) and amplify variation in a given temporal frequency band of interest. For example, in Figure 1 we automatically select, and then amplify, a band of temporal frequencies that includes plausible human heart rates. The amplification reveals the variation of redness as blood flows through the face. For this application, temporal filtering needs to be applied to lower spatial frequencies (spatial pooling) to allow such a subtle input signal to rise above the camera sensor and quantization noise.

Our temporal filtering approach not only amplifies color variation, but can also reveal low-amplitude motion. For example, in the supplemental video, we show that we can enhance the subtle motions around the chest of a breathing baby. We provide a mathematical analysis that explains how temporal filtering interplays with spatial motion in videos. Our analysis relies on a linear approximation related to the brightness constancy assumption used in optical flow formulations. We also derive the conditions under which this approximation holds. This leads to a multiscale approach to magnify motion without feature tracking or motion estimation.

Previous attempts have been made to unveil imperceptible motions in videos. [Liu et al. 2005] analyze and amplify subtle motions and visualize deformations that would otherwise be invisible. [Wang et al. 2006] propose using the Cartoon Animation Filter to create perceptually appealing motion exaggeration. These approaches follow a *Lagrangian* perspective, in reference to fluid dynamics where the trajectory of particles is tracked over time. As such, they rely

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논문 소개

- 주제: Motion Magnification
- 모션 증폭
  - 미세한 움직임 증폭
  - 인간의 눈으로 감지

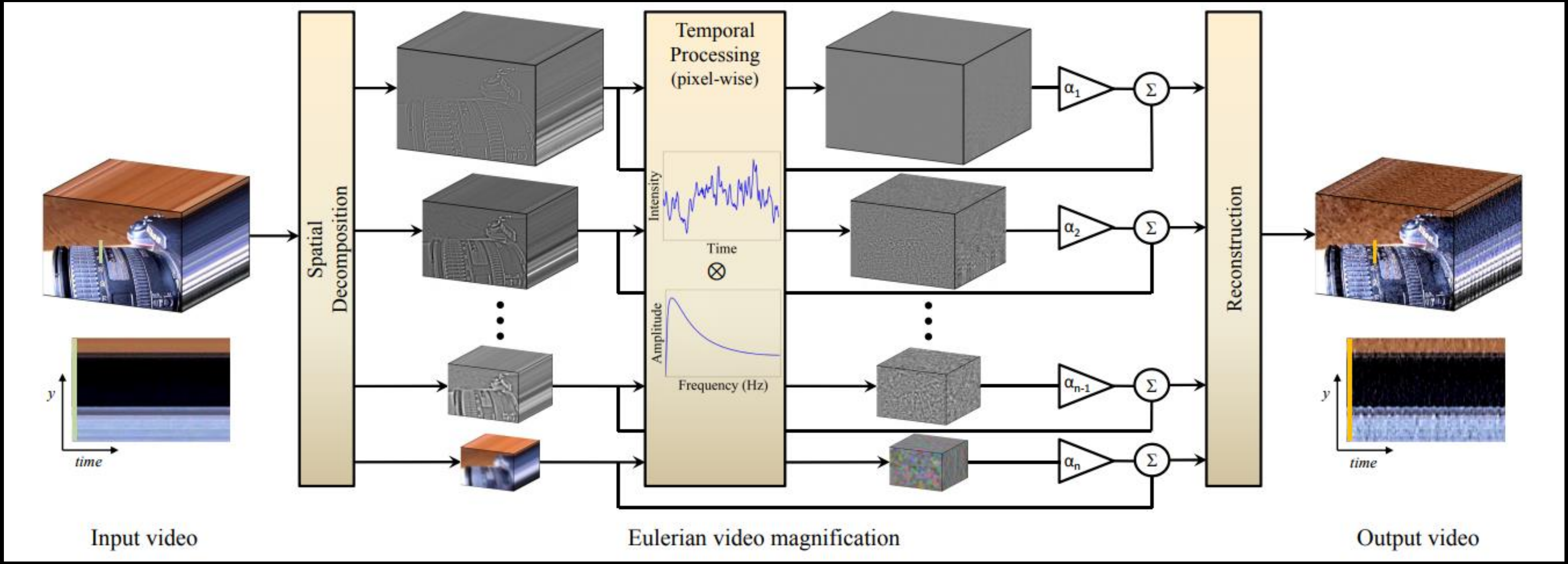
Motion Magnification

Overview

- 오일러 시공간 처리로 비디오 시퀀스 처리
- 시간적 필터링과 공간적 움직임 사이의 연관성 분석

- 증폭

Overview



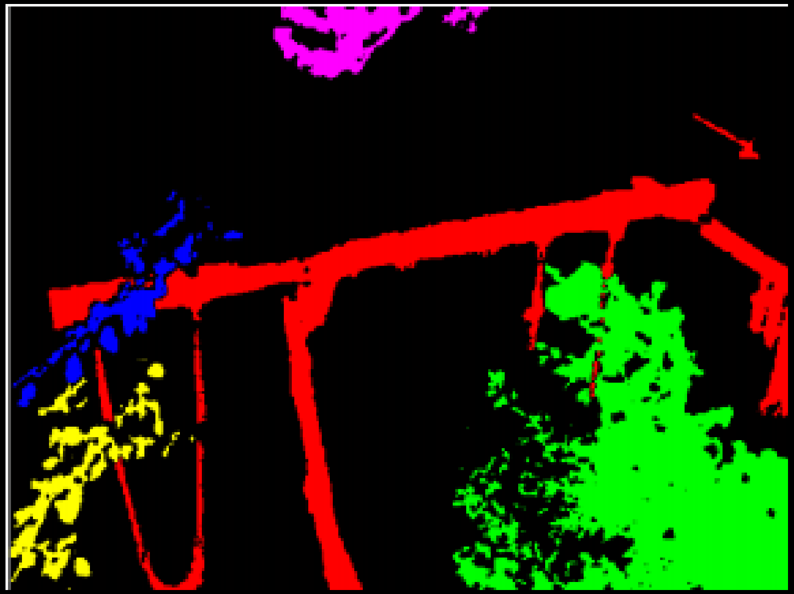
Spatial Decomposition
Temporal Processing (pixel-wise)
Intensity
Time
Amplitude
Frequency (Hz)
Reconstruction
y
time
Input video
Eulerian video magnification
Output video

시공간 비디오 처리

시공간 비디오 처리

- 비디오 시퀀스를 서로 다른 공간 주파수 대역으로 분리
  - 관심있는 주파수 대역의 변화 측정
  - 라플라시안 피라미드로 윤곽선 추출
- 특정 주파수 대역의 시간적 변화 분석, 증폭할 신호 측정
  - 예시) 심장박동: 24 ~ 240 m/s

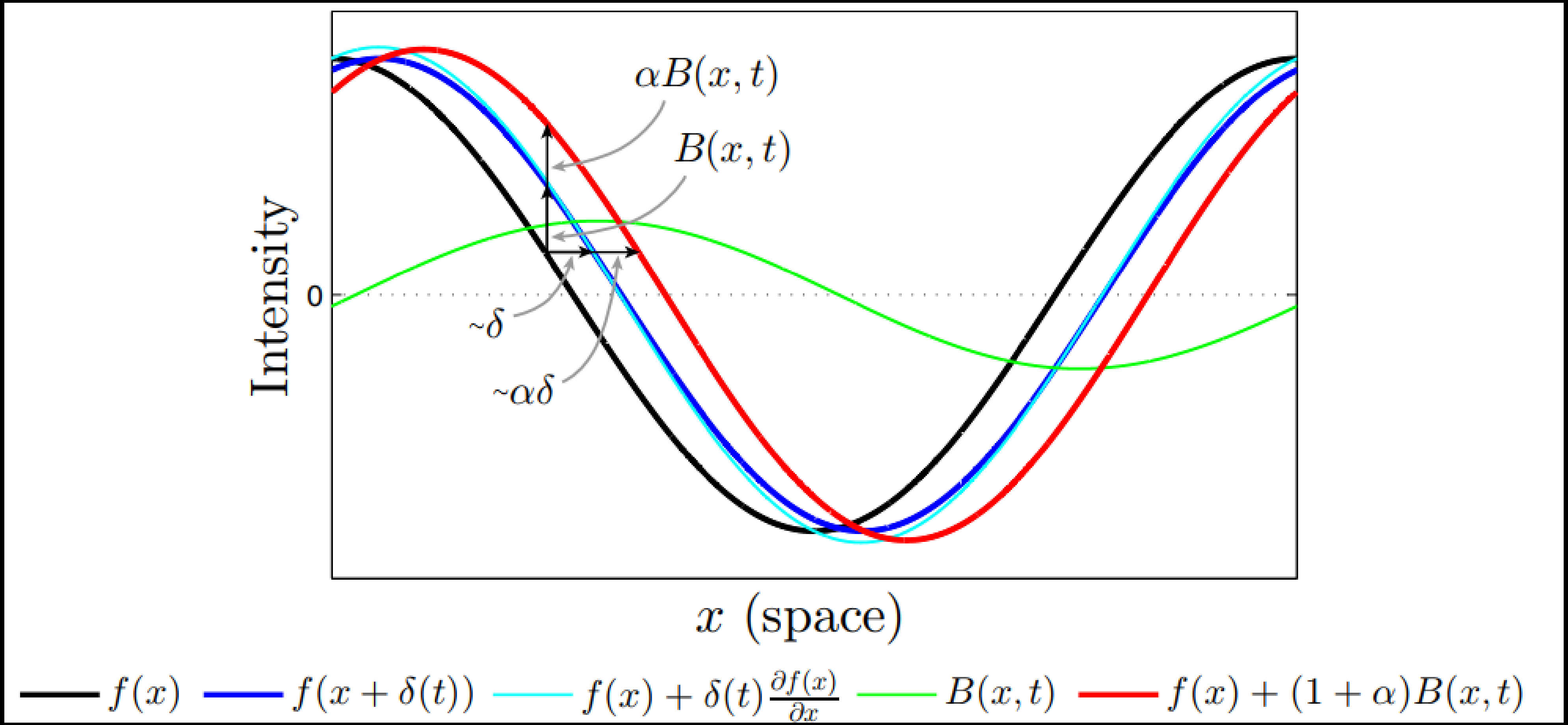
시공간 비디오 처리


증폭

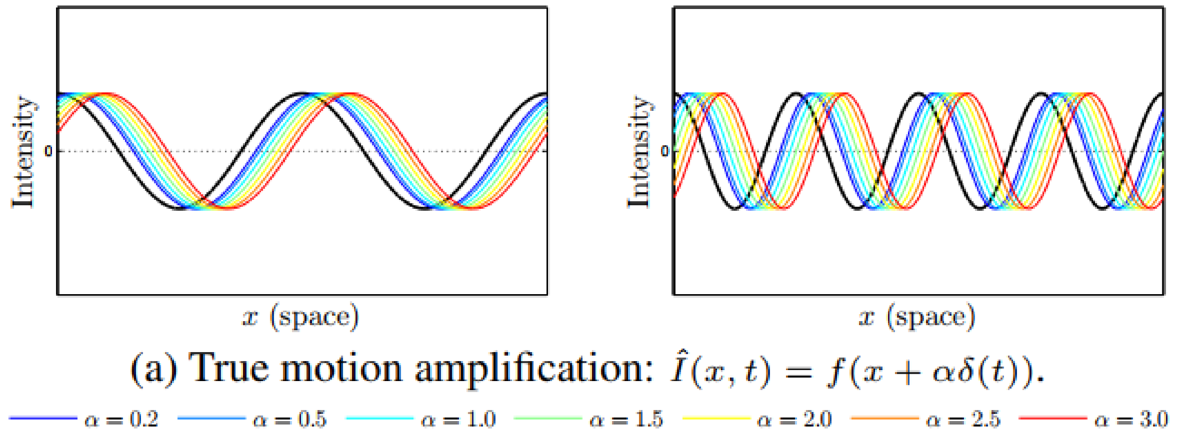
Motion Magnification

증폭



$\alpha B(x,t)$
$B(x,t)$
Intensity
0
~δ
~$\alpha\delta$
x (space)
$f(x)$
$f(x+\delta(t))$
$f(x)+\delta(t)\frac{\partial f(x)}{\partial x}$
$B(x,t)$
$f(x)+(1+\alpha)B(x,t)$

증폭: Temporal filter



(a) True motion amplification: $\hat{I}(x,t) = f(x + \alpha\delta(t))$.

(b) Motion amplification via temporal filtering: $\tilde{I}(x,t) = I(x,t) + \alpha B(x,t)$.

증폭

- $I(x,t)$: 위치 x, 시간 t에서의 이미지 강도(intensity)
- $\delta(t)$: 변위 함수

  이미지 병진운동(translational motion)
- $I(x,t) = f(x + \delta(t))$, $I(x,0) = f(x)$

증폭 과정

- $I(x,t)$: 원래 신호
- $I\^(x,t)$: 합성한(증폭) 신호
- 테일러 확장
- $B(x,t)$: 모든 위치 x에서 $I(x,t)$에 광대역 시간 대역 통과 필터 적용

$$\hat{I}(x,t) = f(x + (1+\alpha)\delta(t))$$

$$I(x,t) \approx f(x) + \delta(t)\frac{\partial f(x)}{\partial x}.$$

$$B(x,t) = \delta(t)\frac{\partial f(x)}{\partial x}.$$

증폭 과정

- 대역 통과 신호($B(x,t)$)를 @만큼 증폭

$$\tilde{I}(x,t) = I(x,t) + \alpha B(x,t).$$

- 다시 $I(x,t)$에 더해 증폭된 신호 생성
- 앞서 만든 식 합체

$$\tilde{I}(x,t) \approx f(x) + (1+\alpha)\delta(t)\frac{\partial f(x)}{\partial x}.$$

$$\tilde{I}(x,t) \approx f(x + (1+\alpha)\delta(t)).$$

$$B(x,t) = \sum_k \gamma_k \delta_k(t) \frac{\partial f(x)}{\partial x}$$

- 증폭된 후 이미지 부드럽게

$$\tilde{I}(x,t) \approx f(x + \sum_k (1+\alpha_k)\delta_k(t))$$

활용 방안 및 향후 계획

Discussion

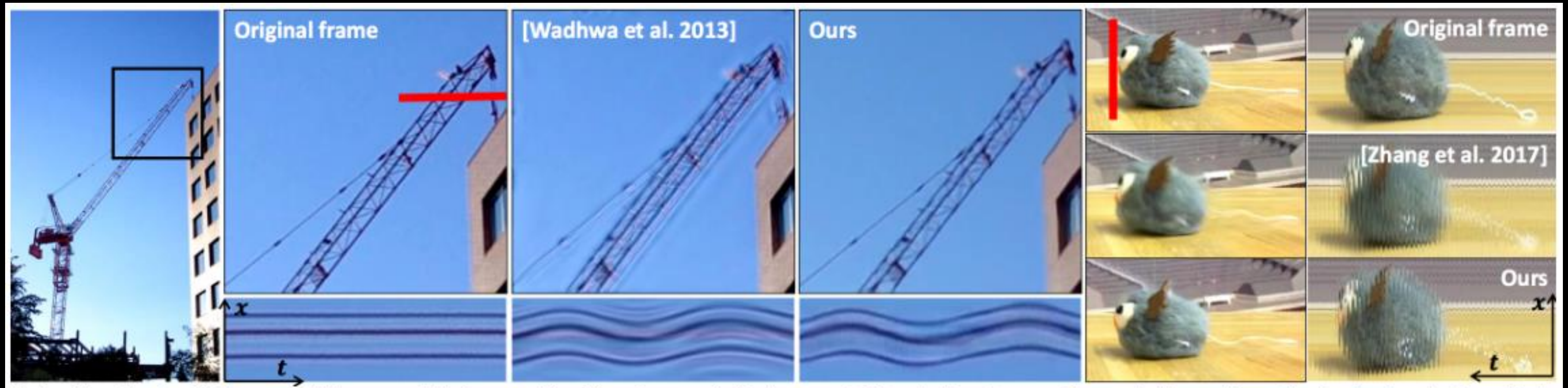
- 논문 예시: Periodic motion(주기 운동)
- Non-periodic motion 적용 가능성 의문

  However, our method can be used to amplify non-periodic motions as well, as long as they are within the passband of the temporal bandpass filter.

팔뚝만 보고 손가락의 움직임 예측

- 팔 근육 움직임 증폭
- 손가락의 움직임 예측
- 특징
  - Non-periodic motion

후속 논문



Motion Magnification While our model learns spatial decomposition filters from synthetically generated inputs, it performs well on real videos with results showing less ringing artifacts and noise. [Left] the *crane* sequence magnified 75× with the same temporal filter as [1] [Right] *Dynamic* mode magnifies difference (velocity) between consecutive frames, allowing us to deal with large motion as did [2] The red lines indicate the sampled regions for drawing x-t and y-t slice views.

- Oh, Tae-Hyun, et al.
- Learning-based video motion magnification
- ECCV 2018

Q&A