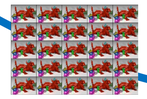
IVMSP-P14.3

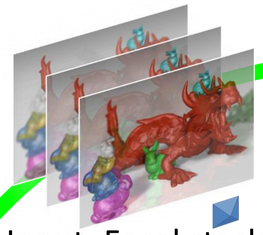
FROM FOCAL STACKS TO TENSOR DISPLAY: A METHOD FOR LIGHT FIELD VISUALIZATION WITHOUT MULTI-VIEW IMAGES

Yuto Kobayashi, Keita Takahashi, Toshiaki Fujii Nagoya University, Japan

Conventional pipeline

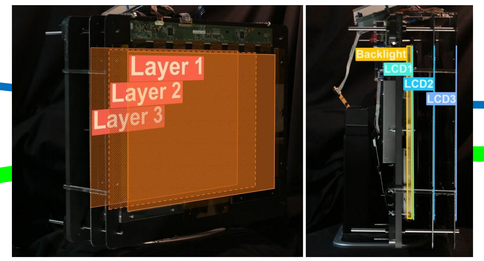


Input: Multi-view images

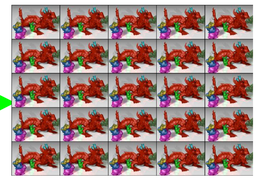


Input: Focal stack

Proposed pipeline



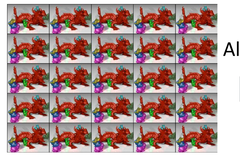
"Tensor Displays"
G. Wetzstein, et al. SIGGRAPH 2012.



Output

We use a focal stack as the input instead of multi-view images.
That greatly reduces the data acquisition cost.

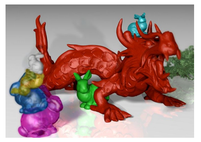
Experiments



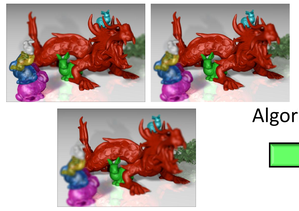
(a) Light field (5x5 views)

Algorithm 1

(c) Layer patterns from light field (a)



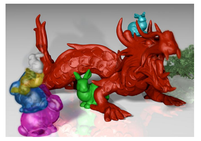
(e) Simulated output using (c)
31.69 [dB]



(b) Focal stack with 3 depths from (a)

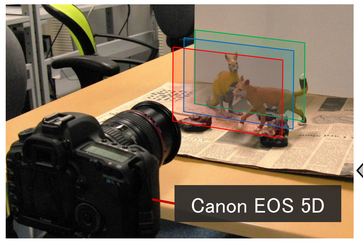
Algorithm 2

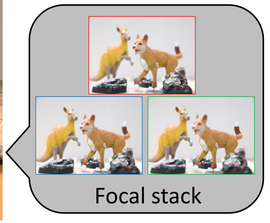
(d) Layer patterns from focal stack (b)



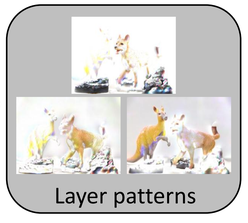
(f) Simulated output using (d)
31.36 [dB]

Displaying real world light field



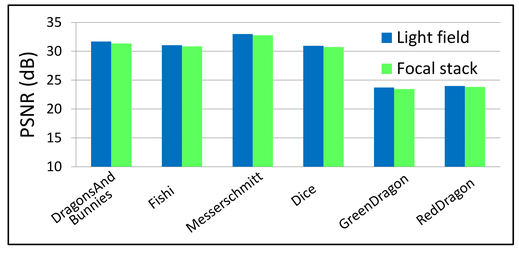


Focal stack

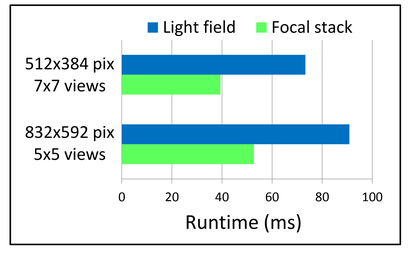


Layer patterns

Our prototype display



Quality of output light field

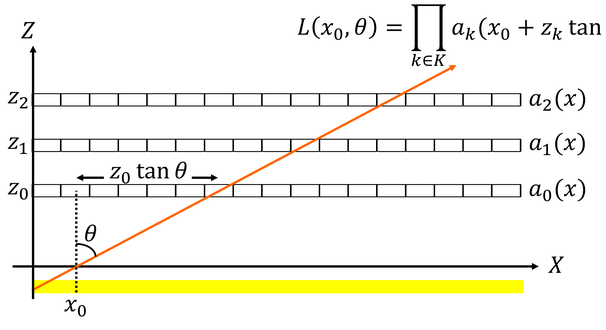


Computational time

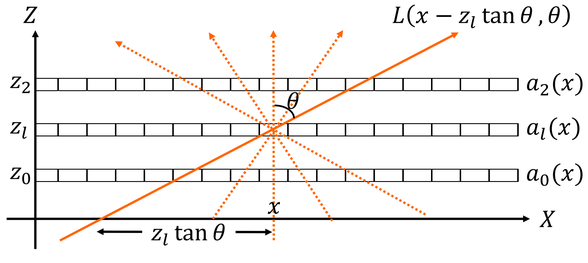
Video

Modeling a Tensor Display

$$L(x_0,\theta)=\prod_{k\in K} a_k(x_0+z_k\tan\theta)$$



Optimize $a_l(x)$



$$\arg\min_{a_k(x)(k\in K)} \int_\Theta \|\underline{\bar{L}(x-z_l\tan\theta,\theta)}-\underline{L(x-z_l\tan\theta,\theta)}\|^2 d\theta$$

$$\underline{L(x-z_l\tan\theta,\theta)}=\prod_{k\in K} a_k(x+(z_k-z_l)\tan\theta)$$
$$=a_l(x)\prod_{k\in K\setminus\{l\}} a_k(x+(z_k-z_l)\tan\theta)$$
$$=\underline{a_l(x)A_l(x,\theta)}$$

Layer pattern optimization

$$\arg\min_{a_k(x)(k\in K)} \int_\Theta\int_X \|\underline{\bar{L}(x,\theta)}-\underline{L(x,\theta)}\|^2\,dxd\theta$$

Input ray — Display's output ray

For a given light field

$$\arg\min_{a_k(x)(k\in K)} \int_\Theta \|\underline{\bar{L}(x-z_l\tan\theta,\theta)}-\underline{a_l(x)A_l(x,\theta)}\|^2 d\theta$$

$$a_l(x)=\frac{\int_\Theta \underline{\bar{L}(x-z_l\tan\theta,\theta)}\,A_l(x,\theta)d\theta}{\int_\Theta \|A_l(x,\theta)\|^2 d\theta}$$

Algorithm 1 Obtain layer patterns from a given light field

Input: $\bar{L}(x,\theta)$
Output: $a_k(x)(k\in K)$
Initialize: $a_k(x)(k\in K)$ with random numbers
Do until convergence
  For $k=1\ldots\|K\|$
    update: $a_k(x)=\frac{\int_\Theta \underline{\bar{L}(x-z_k\tan\theta,\theta)}A_k(x,\theta)d\theta}{\int_\Theta \|A_k(x,\theta)\|^2 d\theta}$
  End
End

For a given focal stack

$A_l(x,\theta)=A_l(x)+\epsilon_l(x,\theta)$ $A_l(x,\theta)$ is smooth along θ

$$a_l(x)\backsimeq\frac{\int_\Theta \underline{\bar{L}(x-z_l\tan\theta,\theta)}\,d\theta}{\int_\Theta A_l(x,\theta)d\theta}=\frac{\boxed{I_l(x)}}{\int_\Theta A_l(x,\theta)d\theta}$$

$I_l(x)$: image focused on z_l

Algorithm 2 Obtain layer patterns from a given focal stack

Input: $I_k(x)(k\in K)$
Output: $a_k(x)(k\in K)$
Initialize: $a_k(x)(k\in K)$ with random numbers
Do until convergence
  For $k=1\ldots\|K\|$
    update: $a_k(x)=\frac{\boxed{I_k(x)}}{\int_\Theta \|A_k(x,\theta)\|^2 d\theta}$
  End
End