

### **VISUALIZING OUT-OF-SIGHT REGIONS-OF-INTEREST** IN A 360 VIDEO USING SPATIAL PICTURE-IN-PICTURE PREVIEWS

### Yung-Ta Lin, Yi-Chi Liao, Shan Yuan Teng, Yi-Ju Chung, Light Chan, Bing





http://www.dailymail.co.uk/sciencetech/article-3011279/F8-app-hints-key-Facebook-plans.html

### "Wow, Italy is so beautiful!"









# is the new trend for sharing f 🔰 🖗 < 🖉 🐶 🇱 📕



# 360 panoramic video

http://www.techspot.com/images2/news/bigir

### ~= experience

gimage/2015/03/2015-03-13-image-13.jpg



# Limited FOV

### For naturally visual experience, only fraction of world is visible

com/uploads/chor set/file/4089708/20150 ebook-360-video-hands-on-3.0.jpg In1.vox-



http://goo.gl/Q7VhTk



# Out-of-sight ROIs

ROI







# Invisible ROIs leads to search problems

### Viewing Window

### ROI

Pokèmon 360 - CATCH 'EM ALL in VR!





### While watching 360 videos

# Notivation WATCH'EM ALL!! ⇒ CATCH'EM ALL!!

ROI









### Viewing Window

ROI

Pokèmon 360 - CATCH 'EM ALL in VR!



# Related Work





### EdgeRadar Halo CHI '07 Gustafson et al. CHI '03 Bausch et al. Arc > Arrow Dynamic targets



### Wedge CHI '08 Gustafson et al. **Avoid Mutual Occlusion**







# However, in 360 videos,

preview of ROI is crucially necessary

### **Mobile Devices**



# CHI '03 Bausch et al. CHI '07 Gustafson et al. CHI '08 Gustafson et al.

### Multi-camera Surveillance



### **Spatial Multi-Video Player** CHI '07 Girgensohn et al. **Spatial Alignment of Multiple Videos**





### **Contextualized Video** VIS '07 Wang et al. Embed Videos with 3D Models

### 12







### Multi-camera Surveillance



### Spatial Multi-Video Player CHI '07 Girgensohn et al. **Spatial Alignment of Multiple Videos**

### Videos on 3D planes proposed in Contexualized Video inspires the design of Outside-In

**Contextualized Video** VIS '07 Wang et al. Embed Videos with 3D Models











### Navigating Panorama with Limited FOV

### Expand a user's FOV



### FlyVIZ VRST '12













### Tell Me Where to Look CHI '16

### SwiVRChair CHI '15





### Shot Orientation Controls UIST '17

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### Navigating Panorama with Limited FOV

### Expand a user's FOV



### FlyVIZ VRST '12





### SparseLightVR/AR CHI '16

### Provide Hint to Target



### Tell Me Where to Look CHI '16

### SwiVRChair CHI '15





### **Shot Orientation Controls UIST '17**

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### Navigating Panorama with Limited FOV

### Expand a user's FOV

# **Limitation** FlyVIZ VRST '12

# Extra Hardware Limit User's Freedom Limited Applicable Scenarios

SparseLightVR/AR CHI '16





### Tell Me Where to Look CHI '16

### SwiVRChair CHI '15



### Shot Orientation Controls UIST '17



# Design

# **Notivation** WATCH'EM ALL!! $\Rightarrow$ CATCH'EM ALL!!

ROI









### Viewing Window

ROI

Pokèmon 360 - CATCH 'EM ALL in VR!





### **Design Considerations**

1. Minimizing the impact to the main content

2. Effectively guiding users to reach off-screen targets 3. Providing detailed information of off-screen content



### 1. Minimizing the impact to the main content





### 2. Effectively guiding users to reach off-screen targets

# Spatial Guidance

# Where are ROIs? #1 Direction #2 Distance

Turn left~ It's close to you actually!

https://goo.gl/oZKZZq





ROIs?

### 3. Providing detailed information of off-screen content

# Picture-in-Picture Ro

Shot in UIST '16 Welcome Reception

In 360 videos, ROIs are different, and can even expire





![](_page_24_Picture_0.jpeg)

### We propose Outside-In

### PIP as Directional Guidance PIP as Distance Guidance

### [PIP as Directional Guidance] PIP as Distance Guidance

### The rabbit is in the left

## **ROI Direction**

# In which direction should the user navigate to

![](_page_27_Picture_3.jpeg)

# How do we calculate the direction?

![](_page_28_Picture_1.jpeg)

![](_page_29_Figure_0.jpeg)

Taipei GPS Coordinates: Latitude: N 25° 1' 58.7'' Longitude: E 121° 33' 55.5''

格陵蘭 加拿大 North 美國 North Pacific Atlantic Ocean Ocean 墨西哥 THE SHORTEST, THE BEST? 玻利維亞、 地圖資料©2017 使用條款

![](_page_29_Picture_3.jpeg)

![](_page_29_Figure_4.jpeg)

# Putting PIP on this path can guide viewers in the shortest path

![](_page_30_Picture_1.jpeg)

![](_page_31_Picture_0.jpeg)

### Visual Cue

![](_page_31_Picture_2.jpeg)

![](_page_32_Picture_0.jpeg)

![](_page_32_Picture_1.jpeg)

![](_page_32_Picture_2.jpeg)

![](_page_33_Picture_0.jpeg)

![](_page_33_Picture_1.jpeg)

![](_page_33_Picture_2.jpeg)

![](_page_34_Picture_0.jpeg)

![](_page_34_Picture_1.jpeg)

![](_page_35_Picture_0.jpeg)

# Instead

![](_page_35_Picture_2.jpeg)


### Longitude

Equirectangular Projection





# Putting PIP on this path can guide viewers in the comfortable path

















### Outer Edge –

### Inner Edge

### Viewport Center







### Outer Edge

### Inner Edge

### Viewport Center







# PIP as Directional Guidance [PIP as Distance Guidance]

### The rabbit is this away

# ROI Distance

# How many degrees should the user navigate to



# How do we calculate the distance?

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### Longitude

Equirectangular Projection



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# How do we show the distance?







# Perspective Projection

Herbert Bayer - ideas about the extended field of vision (1935)



# We use **Tilt** to show the distance.











# not tilt







The PIP tilts as the center of view approaches the off-screen ROI



# It sounds perfect...

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# Limited space for PIPs







# How do we resolve mutual occlusion?























When multiple off-screen ROIs come from same direction



# User Study

# Research Question

- Is Outside-In really helpful?
- Investigate the navigational behavior using Outside-In
  - in comparison to the traditional arrow guidance

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# 360 Videos for Study





# 360 Videos for Study



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# 360 Videos for Study



*Type C. Concurrent multiple ROIs with static positions*  *Type D. Concurrent multiple ROIs with dynamic positions* 

*Type E. Concurrent multiple ROIs with dynamic & static positions* 



# *Type C. Pokémon Concurrent multiple ROIs with static positions*



# *Type D. Help Concurrent multiple ROIs with dynamic positions*







# Interfaces in the Study







### Outside-In

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# Participants & Apparatus

18 Users (8M/10F) iPhone 6s (4.7 inch)

### Study Setting



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## Procedure



### Q3. The awareness level of the storyline

## Subjective Rating

likert scale 1 - 7

- **Q1.** The interference level of the interface
- Q2. The understanding level of the spatial relationship of ROIs
- Q4. The overall preference level of the interface

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Estimated Marginal Means

### Q1: Interference Level

7



75

Estimated Marginal Means

### Q1: Interference Level

7



76

Estimated Marginal Means

#### Q2: Perceiving Spatial Relationship



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Estimated Marginal Means

#### Q2: Perceiving Spatial Relationship





Estimated Marginal Means

### Q3: Understanding Storyline



Estimated Marginal Means

### Q3: Understanding Storyline





Estimated Marginal Means

### Q4: Overall Preference





Estimated Marginal Means

### Q4: Overall Preference





### Q3. The awareness level of the storyline

## Subjective Rating

likert scale 1 - 7

**Q1.** The interference level of the interface *Outside-In ~ Arrow* 

Q2. The understanding level of the spatial relationship of ROIs *Outside-In* > *Arrow* 

*Outside-In* > *Arrow* 

Q4. The overall preference level of the interface *Outside-In* > *Arrow* 





### Qualitative Feedback

Using Arrow

Using Outside-In

#### 606 quotes → coding → themes





## Using Arrow





### easier to search for interested targets



## Using Arrow





# easier to search for interested targets



not knowing what the arrows point to



# easier to search for interested targets



not knowing what the arrows point to

distraction





# easier to search for interested targets



not knowing what the arrows point to



distraction





# l llsing









concentrate on the main screen more and waste less time looking around



### making decisions about switching ROIs

concentrate on the main screen more and waste less time looking around



### making decisions about switching ROIs

understand the spatial relationship between **characters** 

concentrate on the main screen more and waste less time looking around



### making decisions about switching ROIs

understand the spatial relationship between **characters** 

concentrate on the main screen more and waste less time looking around

### Using Outside-In

distraction





## Conclusion:

in a 360 video

- 1. Traditional guidance is not enough
- 2. Especially when there are multiple ROIs
- 3. Even professional video need guidance

Applications





## **Application** 360 Video Player on Touchscreen







## **Application** Tele-Meet: Telepresence Interface



# Discussion

# Automatically Labeling ROIs?





### Face Detection



### Saliency



# Suitable Video Types









# Various using strategies



### P12 - Follow the PIPs



### P9 - Explore other parts

# Inevitable Distraction













# Conclusion
## **VISUALIZING OUT-OF-SIGHT REGIONS-OF-INTEREST** IN A 360 VIDEO USING SPATIAL PICTURE-IN-PICTURE PREVIEWS

## OUTSIDE

## Contributions . We propose this novel visualization technique. 2. a user study shows it outperforms Arrow. 3. two applications are implemented.

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