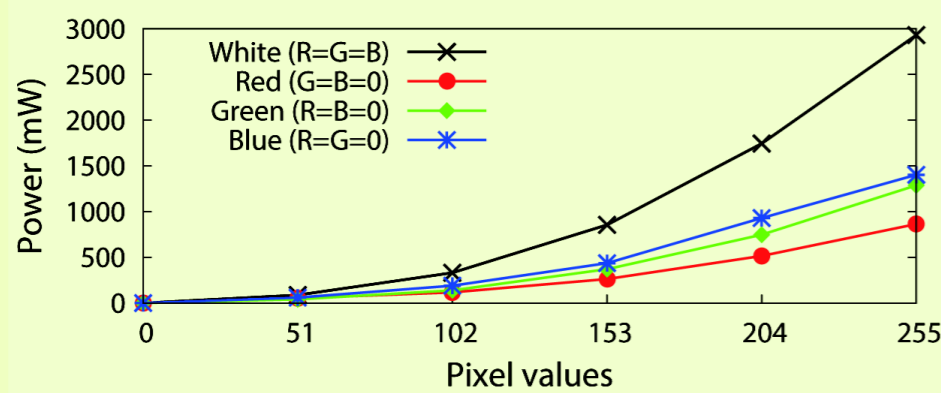


# Catch Your Attention: Quality-Retaining Power Saving on Mobile OLED Displays

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## Motivation

- **OLED is deemed promising technology to replace LCD for mobile displays**
  - It provides brighter colors, wider viewing angles, faster response times, etc.
  - Power consumption increases dramatically with the pixel values of the displayed image
    - Black image ( $\approx 0$ ) vs. White image (2xLCD)



## Inspired by Human Visual Attention

- **Different regions in an image**
  - Receive varying degrees of visual attention
  - Can tolerate different degrees of image distortion



## Contributions

- **Link human visual attention (Itti, SSIM, JND) to OLED power saving**
- **Develop an optimal algorithm w/o accurate power models**
- **Implement an image converter and a power-saving mode on Samsung tablet**

## Quality-Retaining Power Saving

### Visual attention

- Not every region in an image receives the same attention level
- Image can be segmented based on its saliency map into a set of attention regions
- The saliency map indicates a saliency value for each pixel in an image

### Optimal algorithm

- Determines a feasible scaling assignment  $\sigma$  such that the power consumption,  $\sum_{r_i \in R} \sum_{x_k \in r_i} P([x_k \sigma(i)])$ , is minimized.

**Input** :A region set  $R$  with an adjacency matrix  $A$ , as well as critical scaling ratios  $c()$  and A differential constant  $d$

**Output** :A feasible assignment  $\sigma$

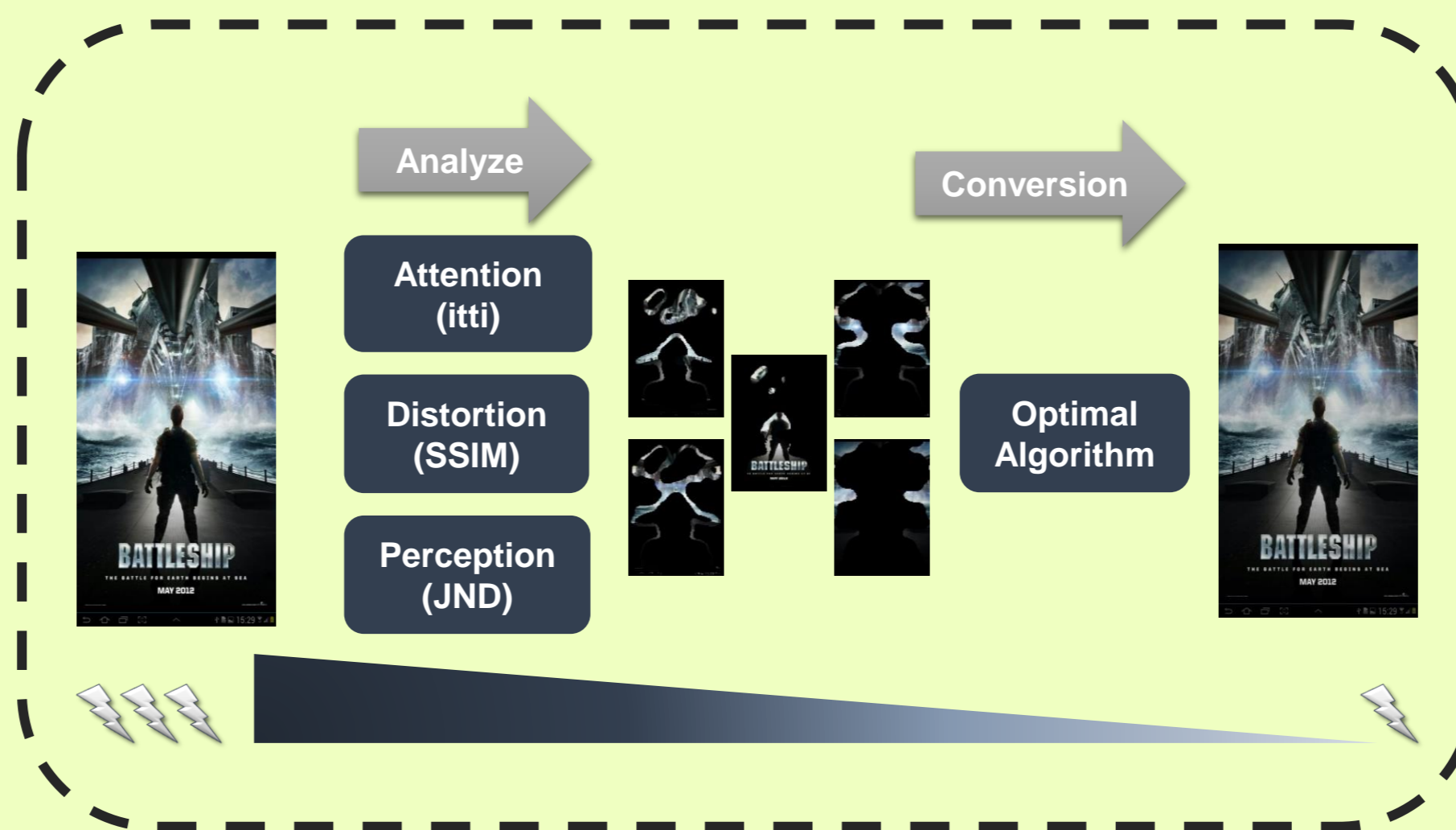
$\sigma \leftarrow c;$   
 $Q \leftarrow R;$   
 While  $Q \neq \emptyset$  do  
    $r_i \leftarrow$  remove from  $Q$  a region whose key is maximum  
   for all  $r_j \in Q$  do  
     if  $A[i,j] = 1$  then  
        $\sigma[j] \leftarrow \max(\sigma[j], \frac{\sigma[i]}{1+d})$   
 return  $\sigma$

### Image distortion

- Different regions in an image receive varying degrees of attention
- Different regions can tolerate different degrees of image distortion.
- Attention regions should be given tolerable distortion in inverse proportion to their attention levels

### Perception

- Lowering the pixel values by applying the critical scaling ratio to each region may result in sharp edges between adjacent regions
- These sharp edges will severely interfere with visual experience
- The difference between the scaling ratios applied to two adjacent regions should be limited



(a)Unlimited



(b)Limited

## Experiments

### 4 images on Samsung Galaxy Tab 7.7

- Different characteristics in terms of luminance and saliency
- **Performance Metrics**
  - Execution time (second) and power consumption (watt)
- **Comparison**
  - A grid-based approach [DAC'12]

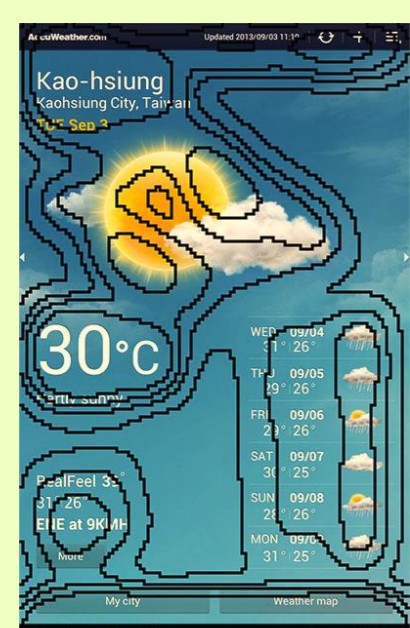
### Comparison

Execution time (seconds)

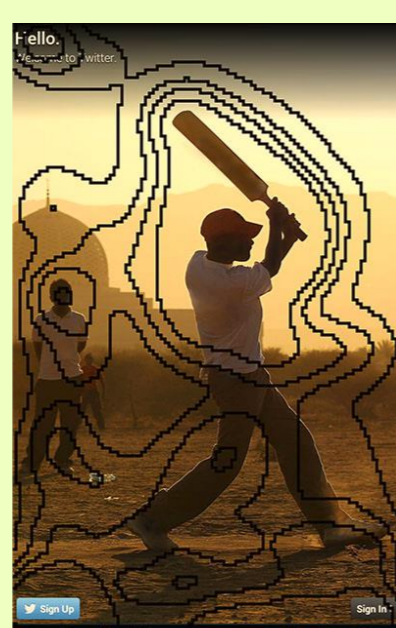
	GRID	CURA
Image Converter	27~219	7.6~8.8
Power-Saving Mode	0.97~4.77	0.72~0.811

Power consumption (watts)

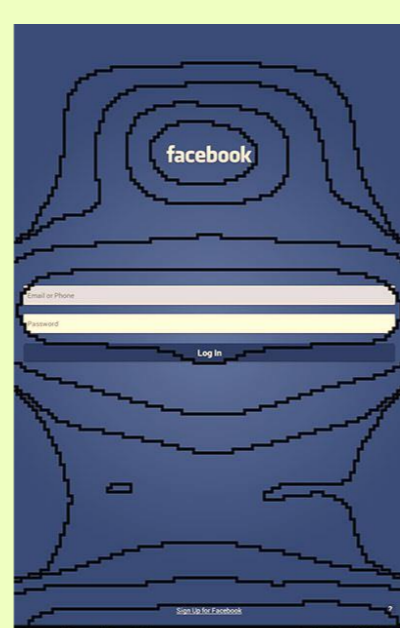
	GRID	CURA
Image Converter	237~648	284~572
Power-Saving Mode	362~797	305~595



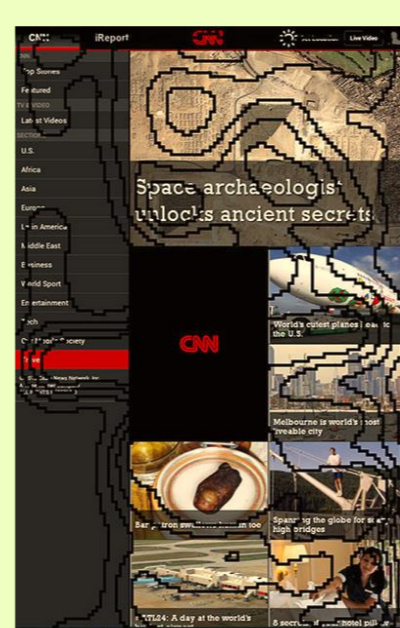
(a)Weather



(b)Twitter



(c)Facebook



(d)CNN

## Conclusion

- **We introduce visual attention into the quality-retaining power-saving design on mobile OLED displays**
- **We present CURA to realize the notion and have implemented two application scenarios**
  - Samsung Galaxy Tab 7.7 can **save 38-42% OLED power** while retaining visual quality
- **Visual quality**



(a)Original



(b)GRID



(c)CURA