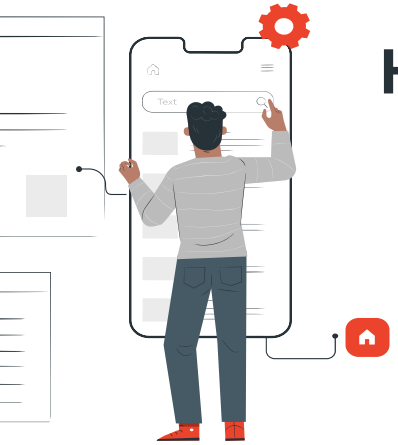
Automated Power-saving User-interfaces for Application Designers

2025 30th Asia and South Pacific Design Automation Conference



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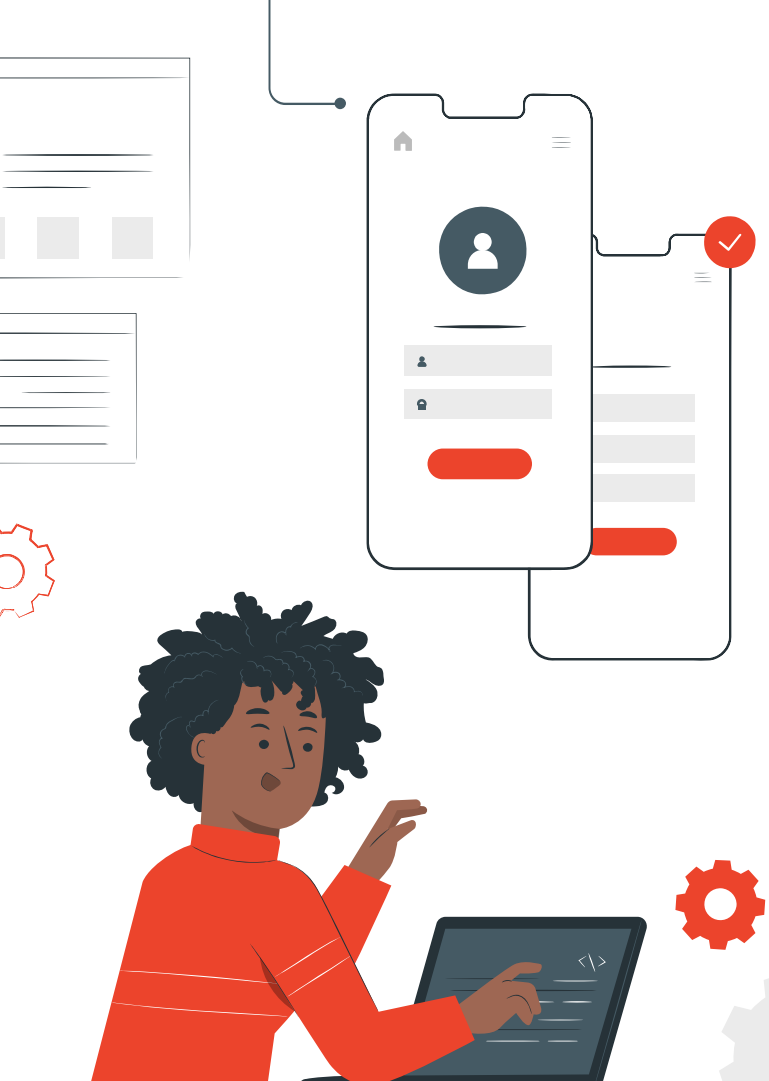


01

INTRODUCTION

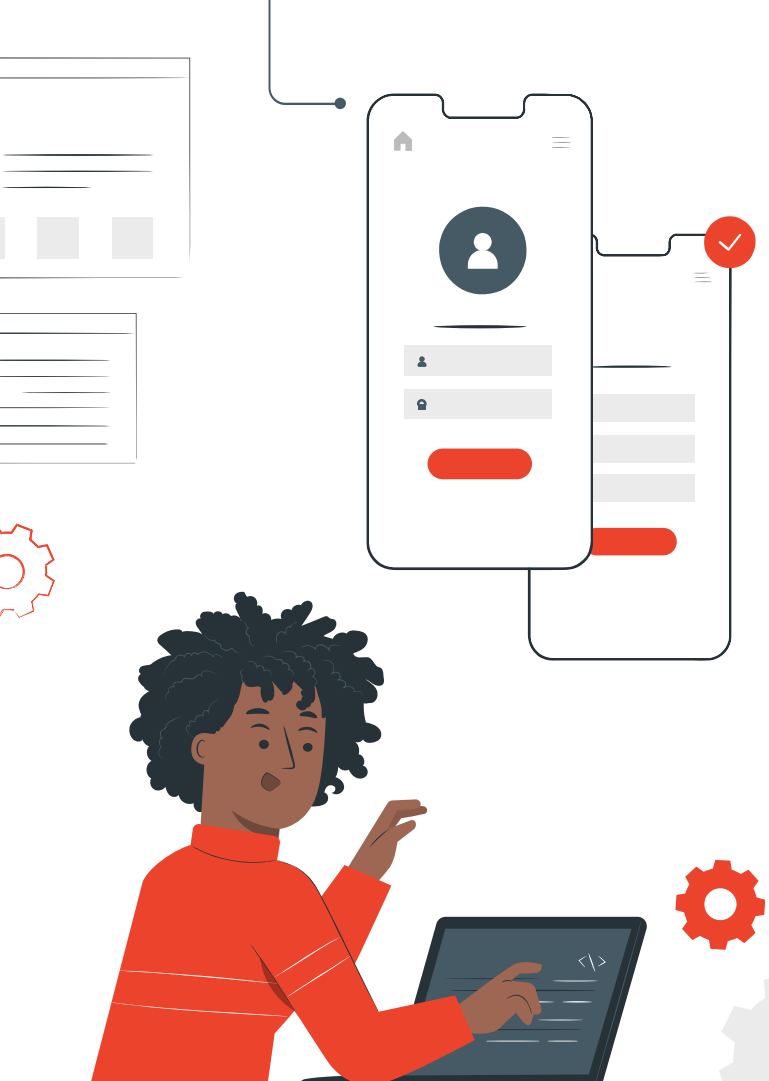
INTRODUCTION

- Mobile devices are essential for daily tasks.
  - So, figuring out how to save power on smartphones has become a really important issue.

- We proposed a method to reduce power consumption in mobile systems while preserving the UI guidance provided by UI designers.

INTRODUCTION

- Using Human Visual System (HVS) Insights:
  - Optimize UI guidance
  - Identify key elements
  - Reduce power consumption
  - Maintain global and local thresholds
- **Contribution**:
  - Our method can reduce power by 3% to 41% while maintaining UI guidance.
  - Is the first to focus on UI guidance, an important factor valued by UI designers.



02

RELATED WORK AND DESIGN CHALLENGES

RELATED WORK

H.-C. Chang et al.

FLASH — Save power by transforming colors in unattended areas during rapid scrolling.

M. Linares-Vásquez et al.

GEMMA — Create energy-efficient color palettes for Android GUI.

⚠ Limitation:

Overlook UI design details, impacting user experience.

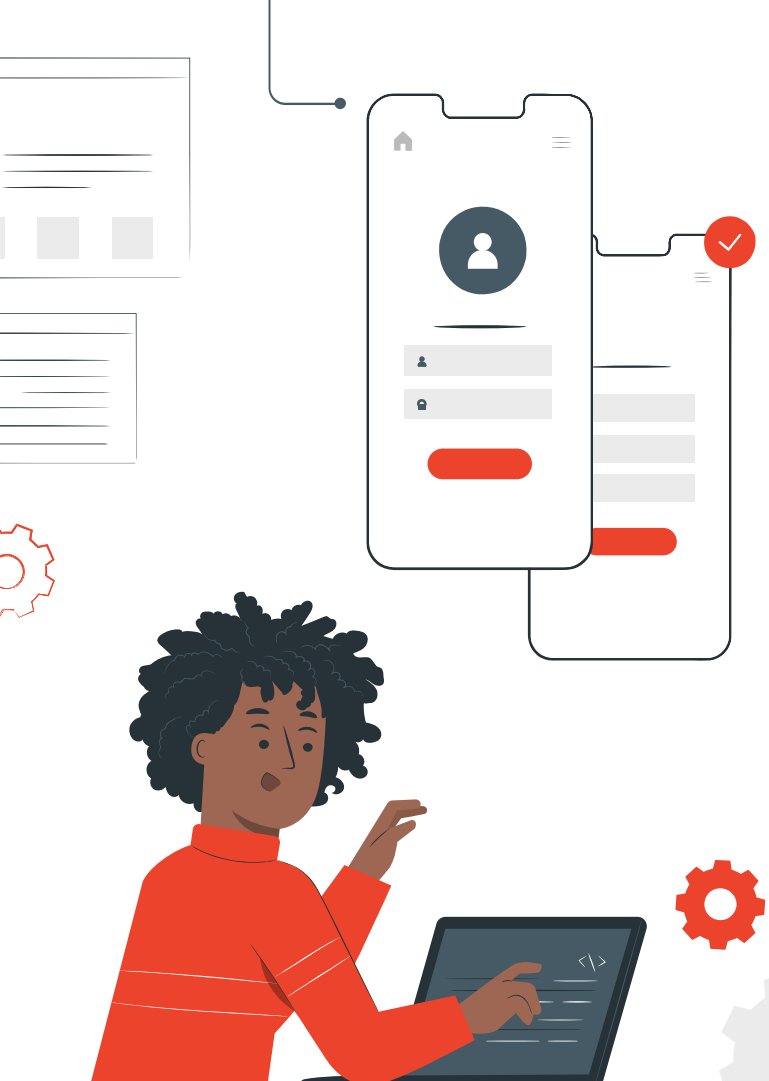
→ Our method ensures the original UI design is preserved without compromising user guidance.

DESIGN CHALLENGES

Efficiently determine which elements to display on the UI during design.

Effectively establish guidance for UI elements.

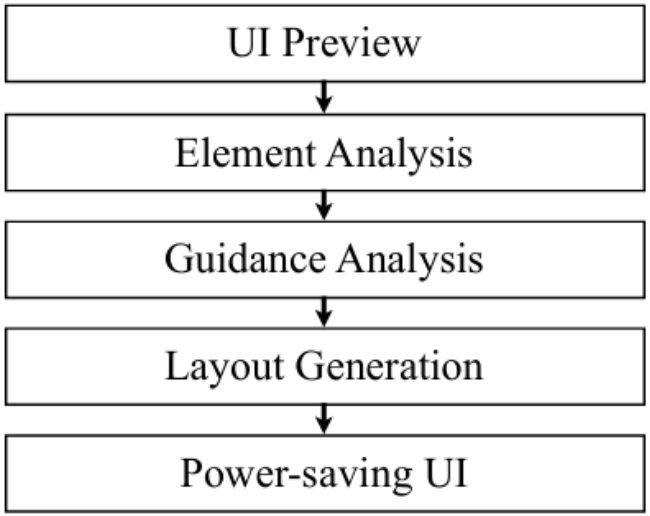
Reduce UI power consumption while maintaining guiding functionality.



03

POWER-SAVING USER-INTERFACES

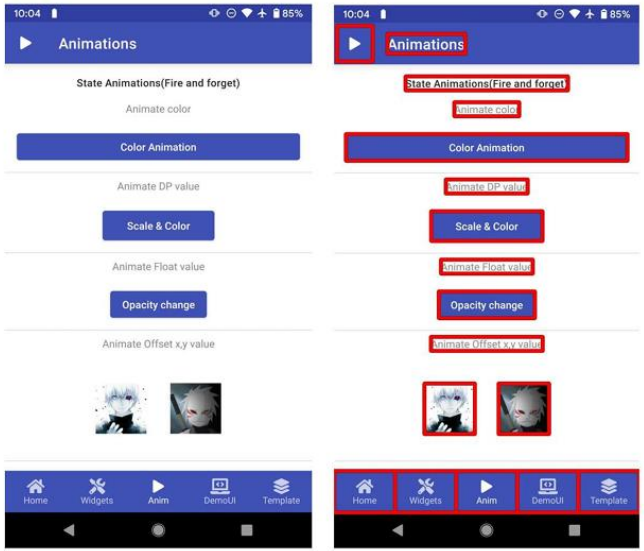
DESIGN OVERVIEW



- UI designers primarily work on PCs.
- The design phase is completed on PCs.

ELEMENT ANALYSIS

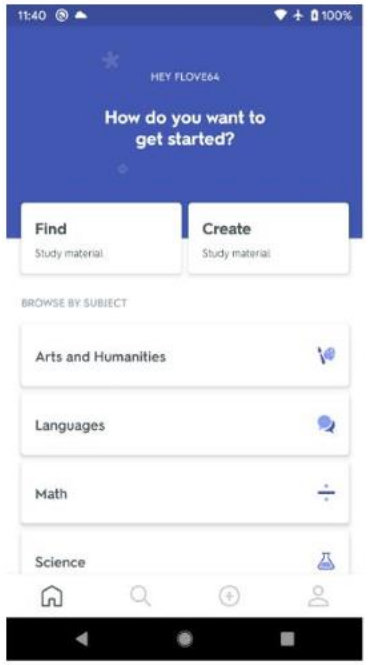
- We leverage an Android testing framework, **UI Automator**, to perform this analysis.
- By parsing XML documents
  - We can determine the positions of UI elements (e.g., buttons, text).

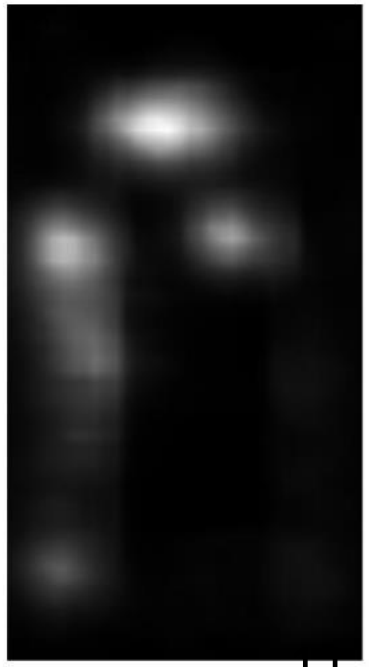


Developers

GUIDANCE ANALYSIS

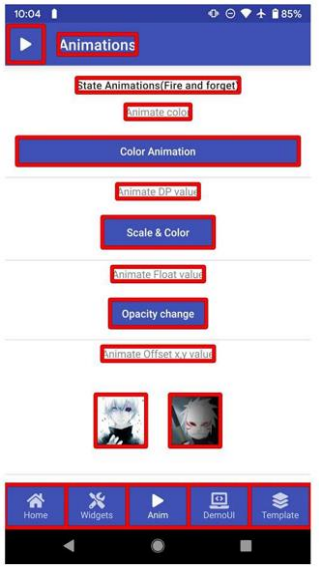
- The guidance analysis process assesses the attention distribution [illegible] preview's guidance.
  - Saliency values of the [illegible] in the UI preview
- HVS models commonly u[illegible] features such as color, b[illegible] orientation to create salie[illegible]

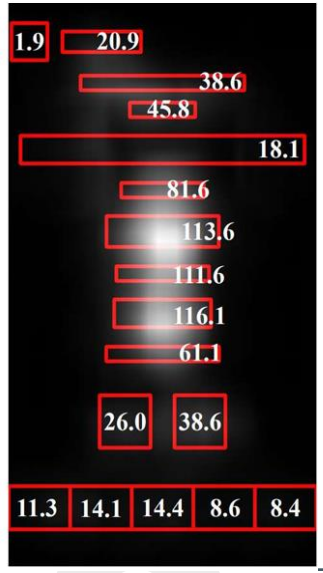




GUIDANCE ANALYSIS

- Saliency values are defined at the pixel level.
- UI elements span multiple pixels in previews.
- We average saliency values within each UI element's area to determine its overall saliency.





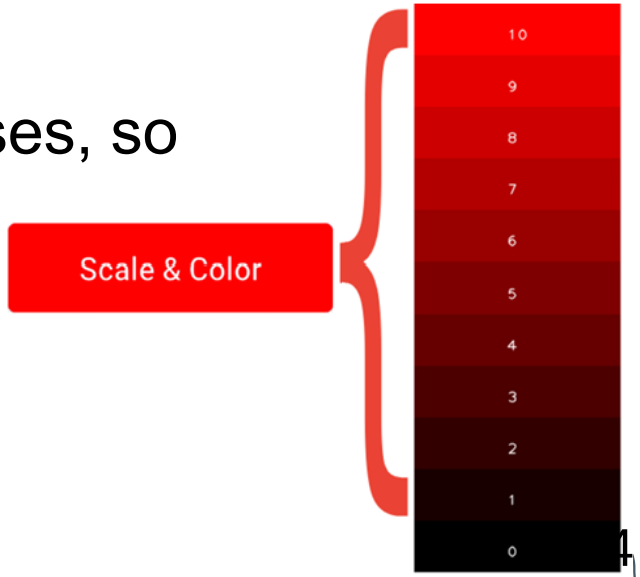
POWER-SAVING LAYOUT GENERATION

- We focus on designing a power-saving UI layout while preserving its UI guidance.

- Ensure the variance in guidance between the power-saving layout and the UI preview stays within a predefined threshold.

COLOR LEVELS

- Divide each element's color into 10 levels.
- Level 10 is the element original color, while level 0 means black.
- Essentially, as the level decreases, so does power consumption.



SALIENT ELEMENTS

- We define **Salient Elements** to ensure that high-attention elements maintain their visual importance.

- **Salient Elements** are the Top N UI elements, determined by their saliency values.

Salient Elements → **Higher saliency values**

POWER-SAVING LAYOUT GENERATION

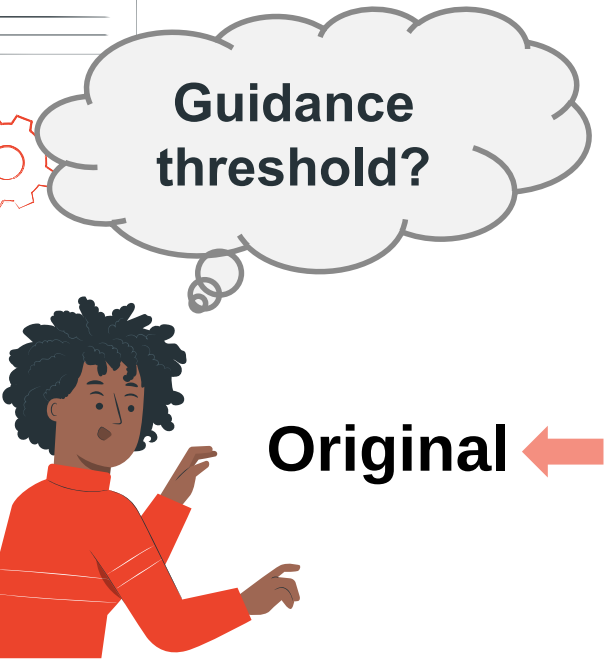
How can we evaluate saliency?

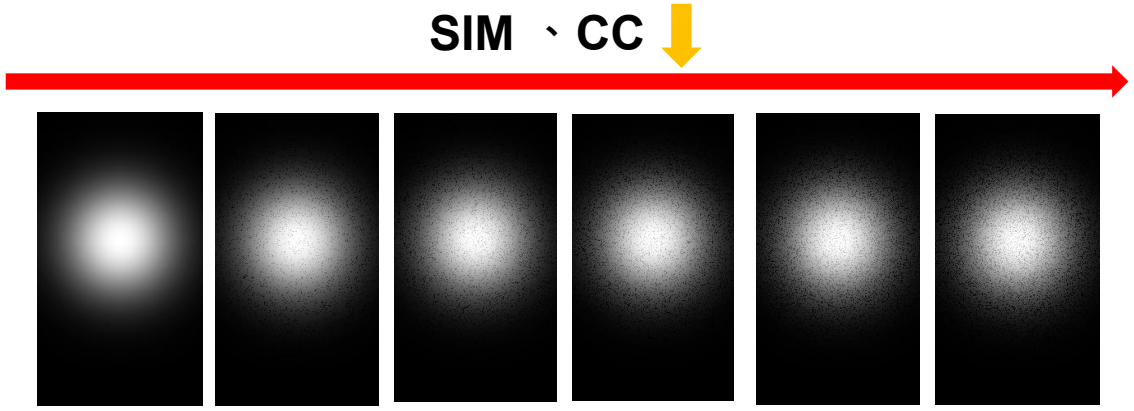
- We adopt two specific saliency assessment models, i.e., **SIM()** and **CC()** , as our thresholds.

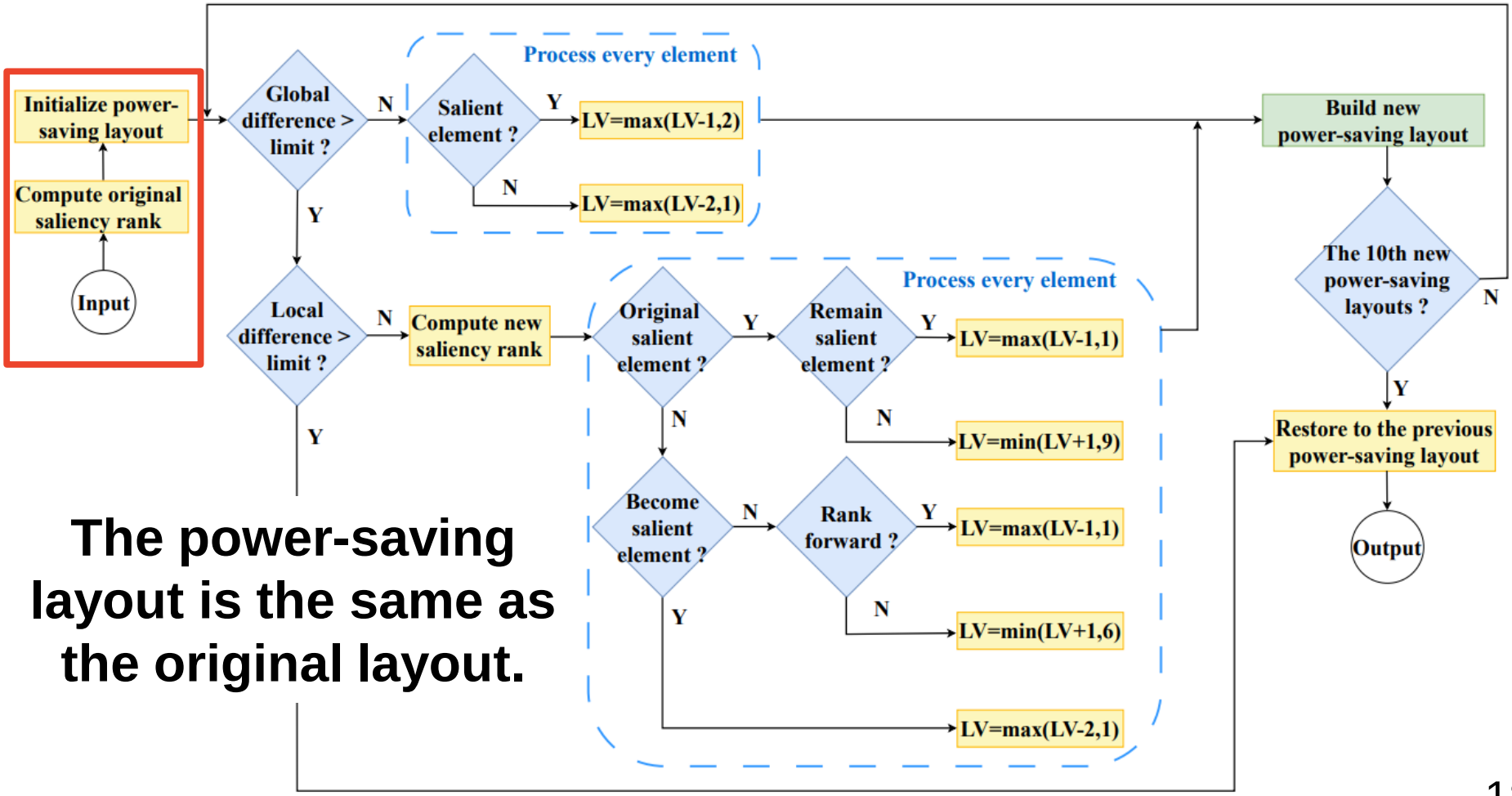
- **SIM() - > Global guidance differences**
- **CC() - > Local guidance differences**

POWER-SAVING LAYOUT GENERATION

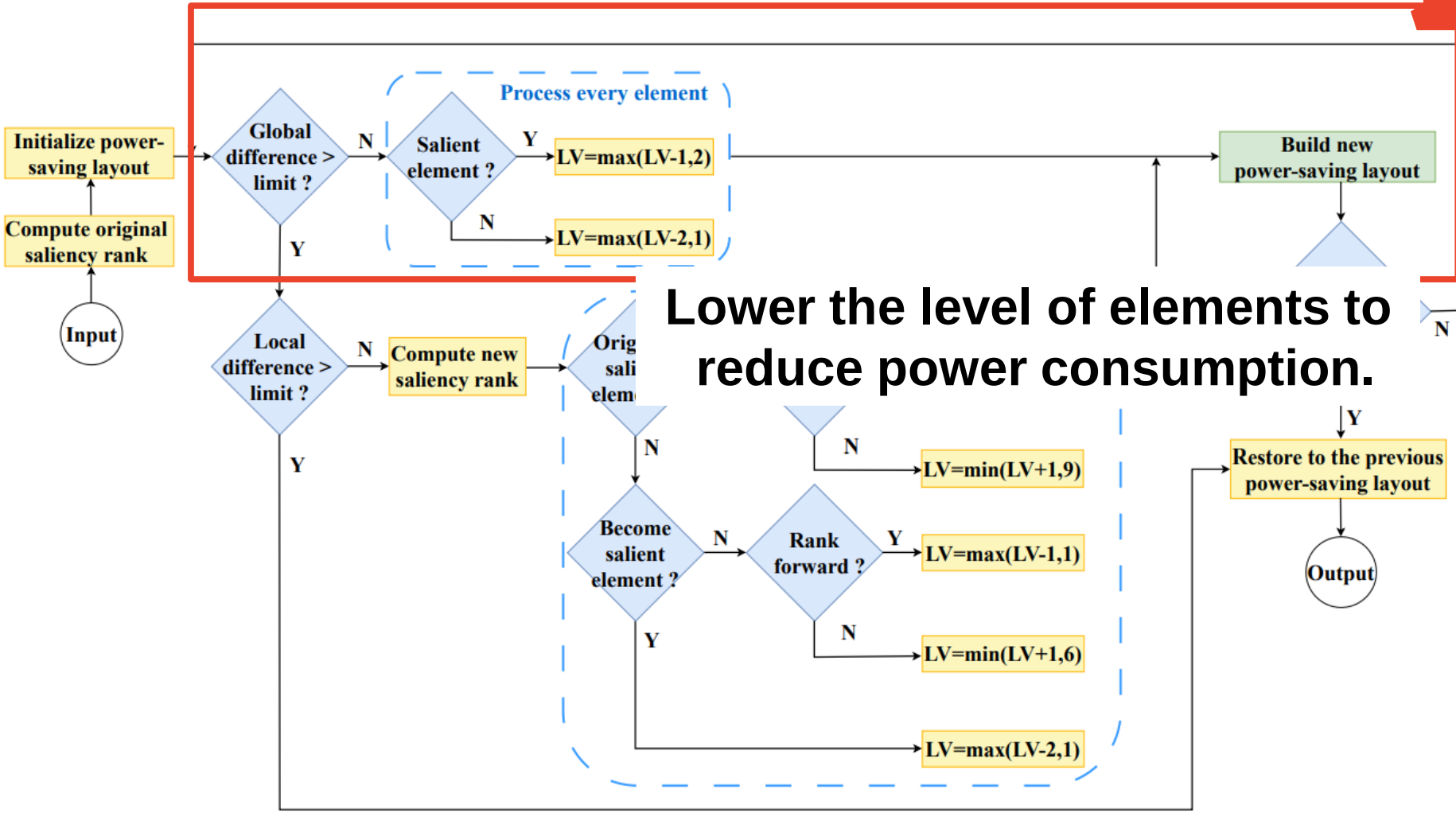
- The guidance threshold is divided into five levels.
  - A higher % means a greater difference from the original image.
  - A higher % results in a smaller threshold



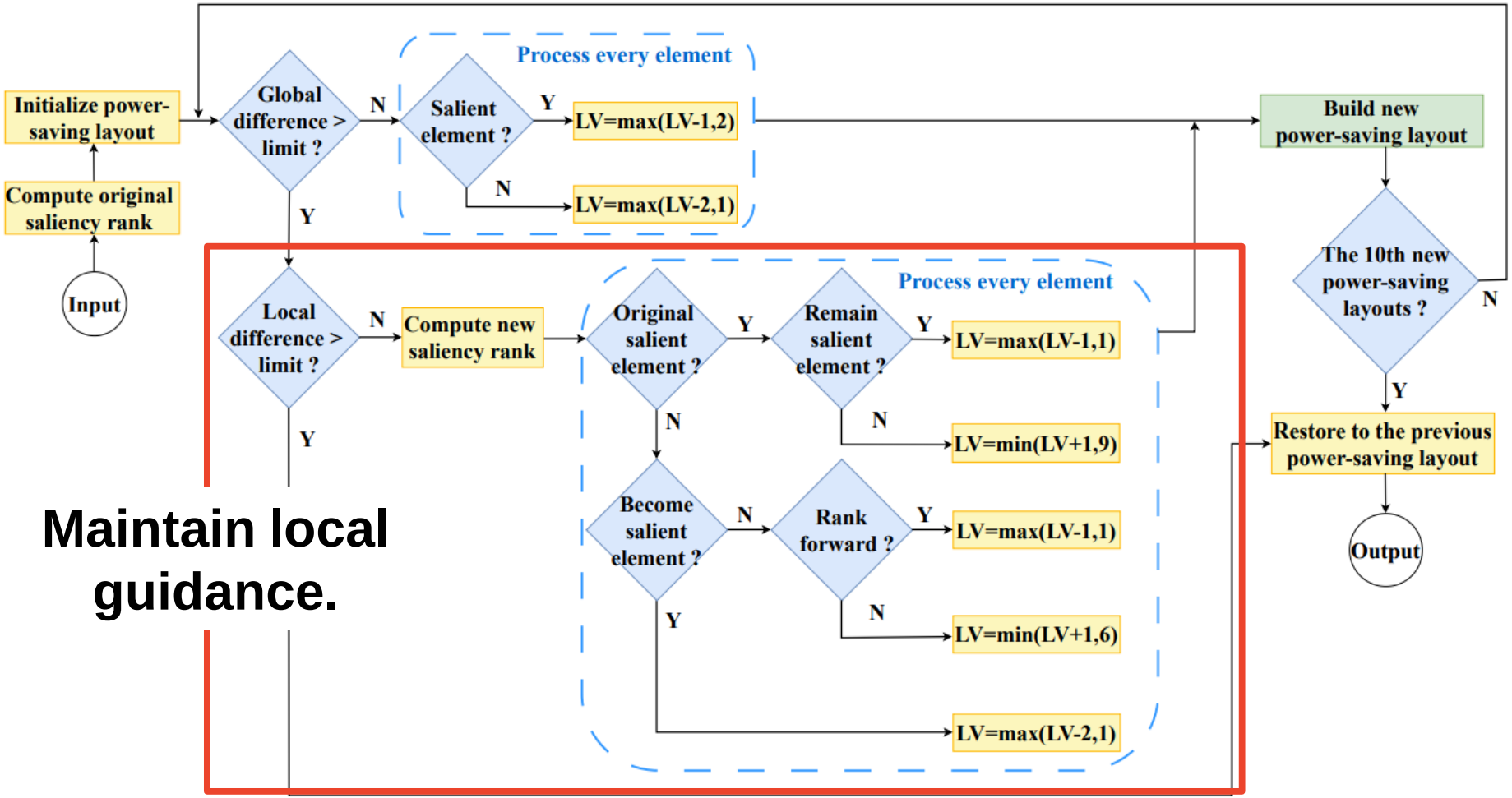




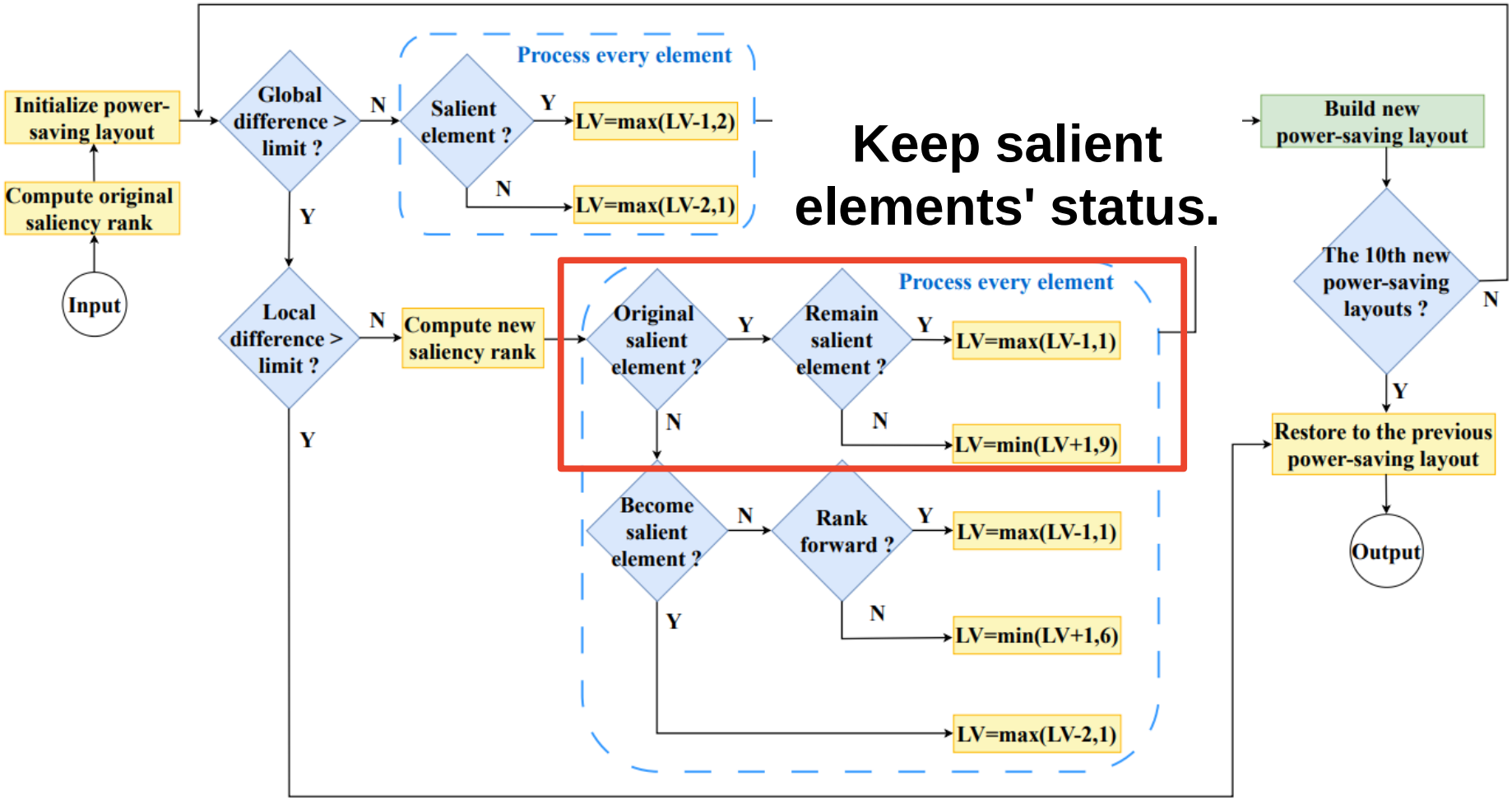
The power-saving layout is the same as the original layout.

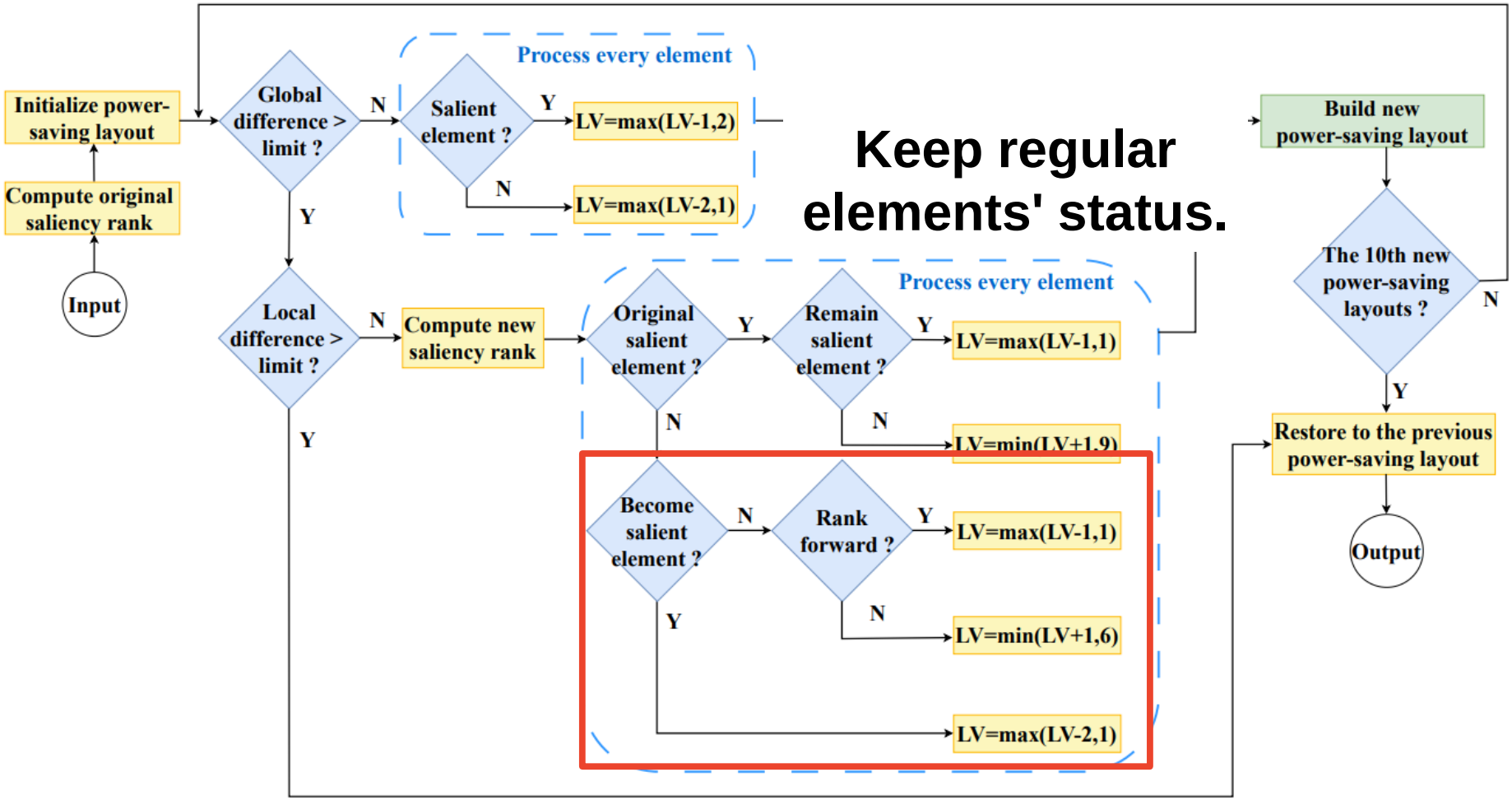


Lower the level of elements to reduce power consumption.

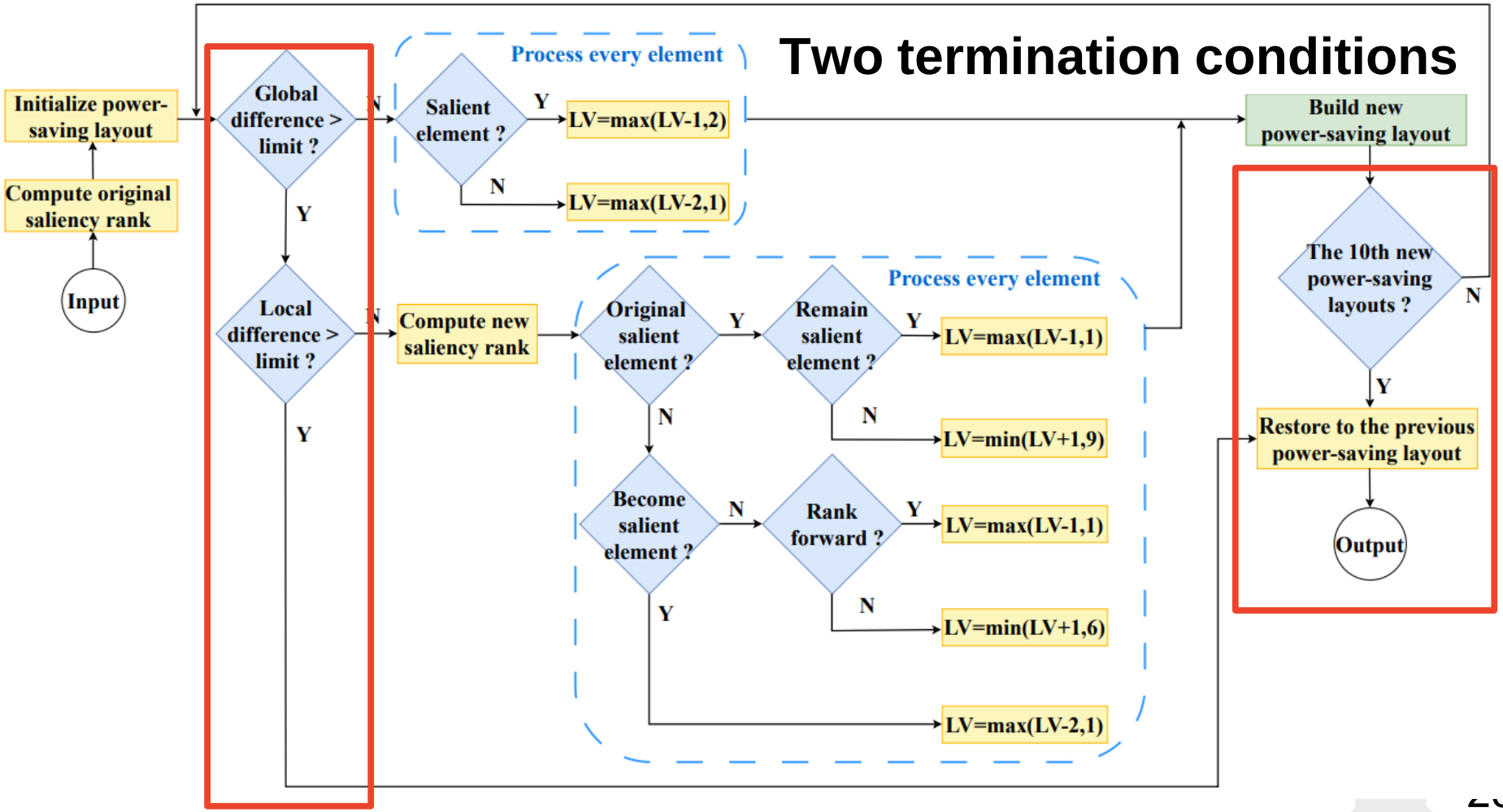


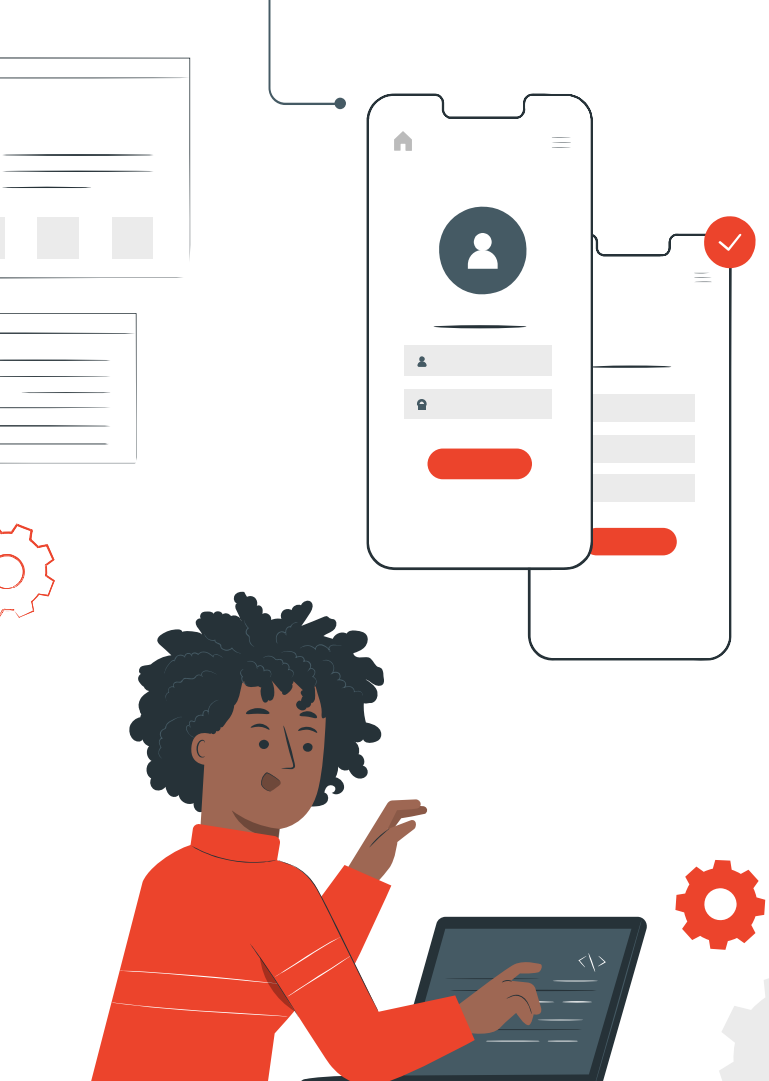
Maintain local guidance.


Initialize power-saving layout
Compute original saliency rank
Input
Global difference > limit ?
N
Y
Process every element
Salient element ?
Y
LV=max(LV-1,2)
N
LV=max(LV-2,1)
Local difference > limit ?
N
Compute new saliency rank
Y
Process every element
Original salient element ?
Y
Remain salient element ?
Y
LV=max(LV-1,1)
N
LV=min(LV+1,9)
Become salient element ?
N
Rank forward ?
Y
LV=max(LV-1,1)
N
LV=min(LV+1,6)
Y
LV=max(LV-2,1)
Keep salient elements' status.
Build new power-saving layout
The 10th new power-saving layouts ?
N
Y
Restore to the previous power-saving layout
Output


Initialize power-saving layout
Compute original saliency rank
Input
Global difference > limit ?
N
Y
Process every element
Salient element ?
Y
LV=max(LV-1,2)
N
LV=max(LV-2,1)
Local difference > limit ?
N
Compute new saliency rank
Y
Process every element
Original salient element ?
Y
Remain salient element ?
Y
LV=max(LV-1,1)
N
LV=min(LV+1,9)
Become salient element ?
N
Rank forward ?
Y
LV=max(LV-1,1)
N
LV=min(LV+1,6)
Y
LV=max(LV-2,1)
Keep regular elements' status.
Build new power-saving layout
The 10th new power-saving layouts ?
N
Y
Restore to the previous power-saving layout
Output

Two termination conditions



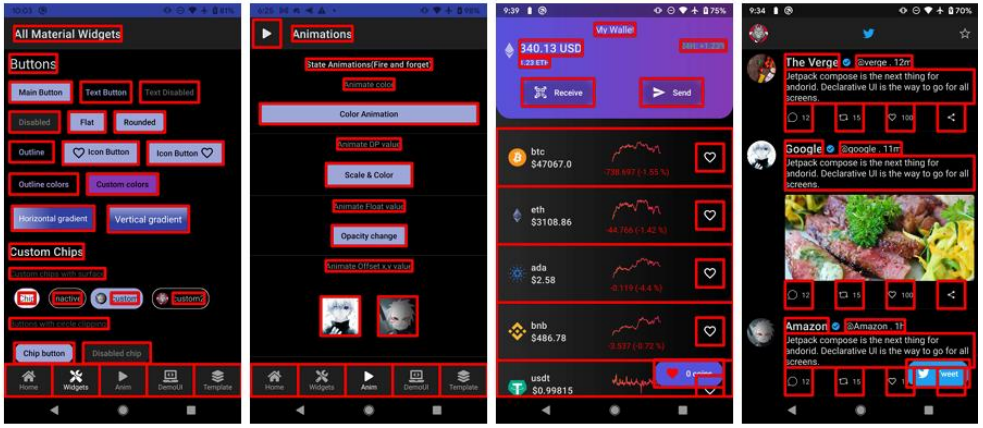


04

PERFORMANCE EVALUATION

Experiment setup

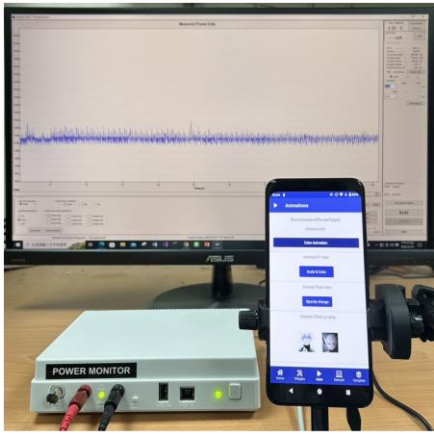
- Google Pixel 4 XL
- We crafted four distinctive UI previews, i.e., Basic, Special, Crypto, and Twitter.



(a) Basic (b) Special (c) Crypto (d) Twitter

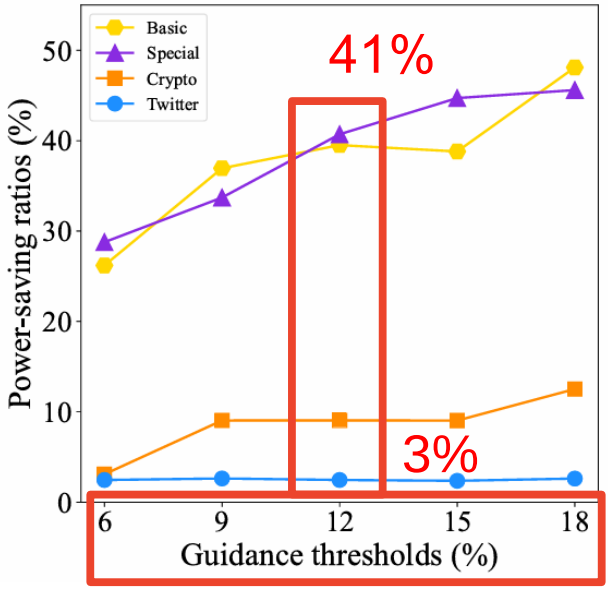
Experiment setup

- Monsoon solutions power monitor
- Each UI was run for 60 seconds.
- Results are averaged over 5 experiments.
- Power-saving ratios are calculated by comparing consumption with and without our design.



GUIDANCE THRESHOLDS AND POWER-SAVING RATIOS

- When guidance threshold is at 12%, the power-saving rate ranges between 3% and 41%.



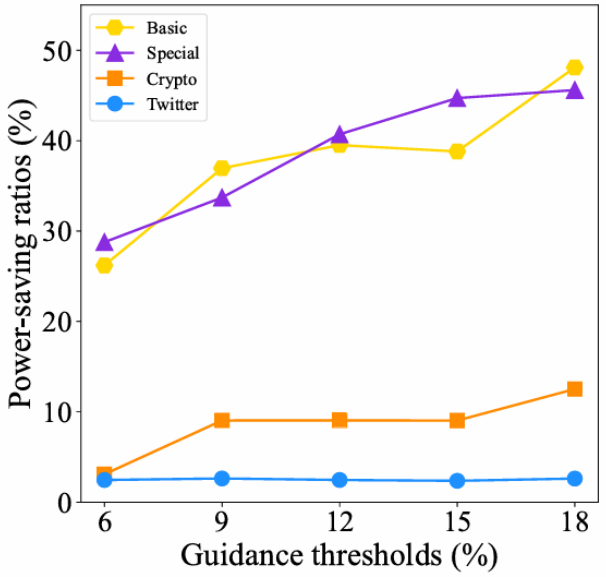
GUIDANCE THRESHOLDS AND POWER-SAVING RATIOS

- An upward trend in power-saving ratios as the guidance thresholds increase.
- Higher thresholds allow more guidance differences, leading to lower target levels.

Higher guidance thresholds

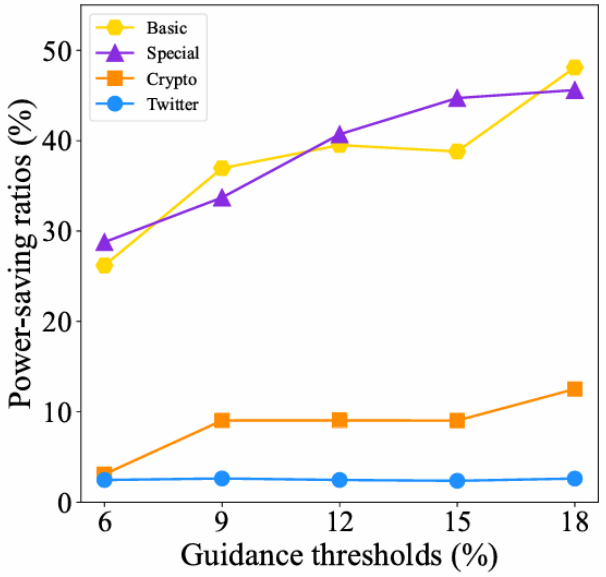
↓

Higher power-saving ratios



GUIDANCE THRESHOLDS AND POWER-SAVING RATIOS

- **Basic** and **Special** consistently show the highest power-saving ratios.
  - Largest area ratio of adjusted elements.
- **Twitter** has the lowest power-saving ratios.
  - Smallest area ratio of adjusted elements.



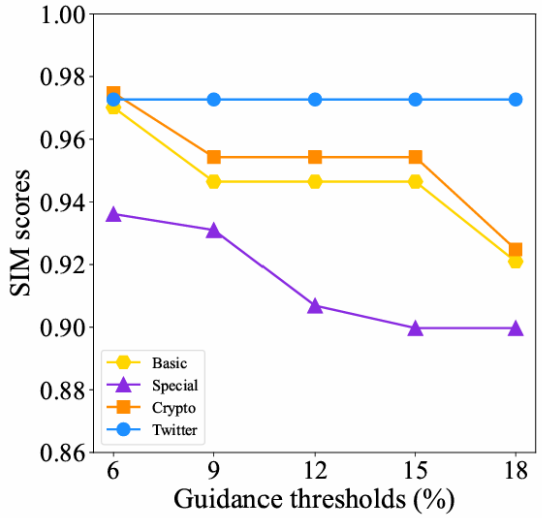
Larger area ratio of adjusted elements → **Higher power-saving ratios**

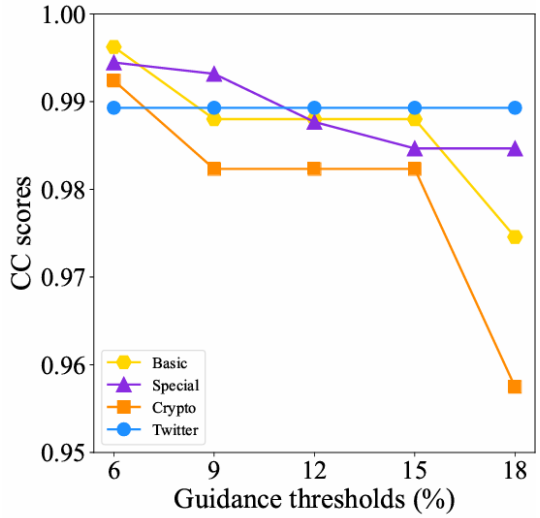
GUIDANCE THRESHOLDS AND SIM / CC

- SIM and CC scores typically remain constant or decrease with increasing guidance thresholds.

Higher guidance thresholds → **Bigger guidance differences**

→ **Lower SIM and CC scores**



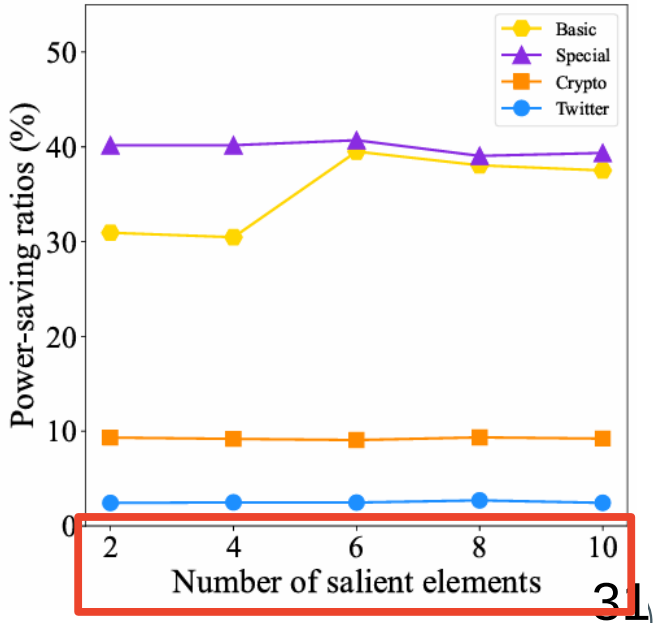


NUMBER OF SALIENT ELEMENTS AND POWER-SAVING RATIOS

- Power-saving ratios remain stable, even as the number of salient elements increases.
- Small adjusted area of the two elements
  - little impact on power consumption.

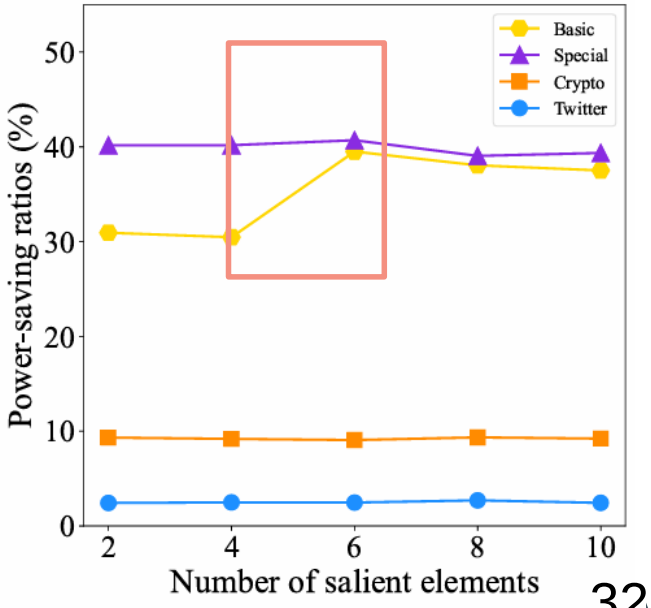
Regardless of the number of salient elements.

Power-saving ratio remains stable.



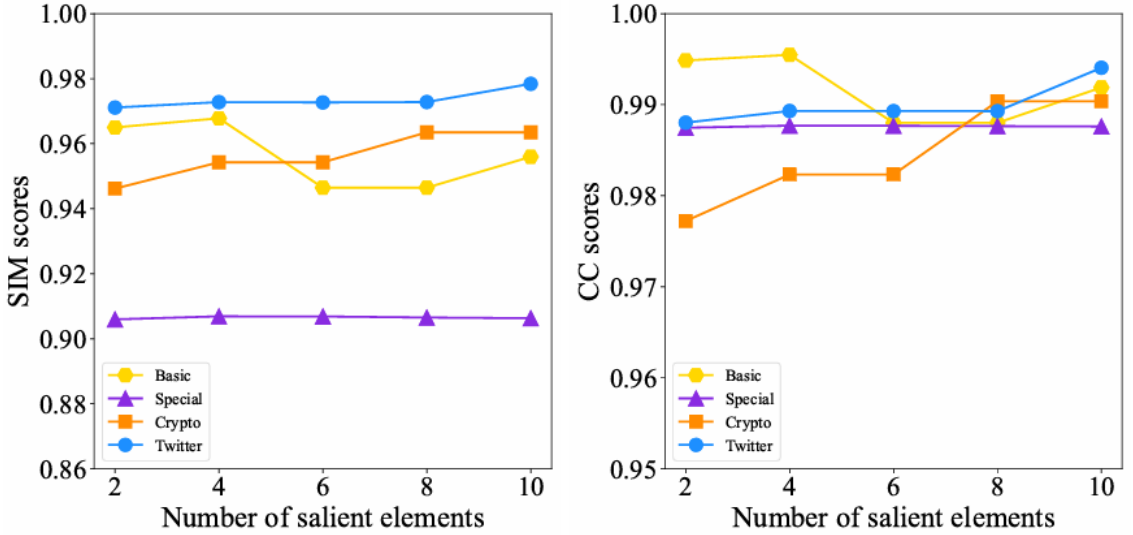
NUMBER OF SALIENT ELEMENTS AND POWER-SAVING RATIOS

- When the number of salient elements reaches 6, the power-saving ratio for Basic noticeably increases.
  - The guidance difference generated in each adjustment loop decreases.
  - The elements are adjusted down by one more level.



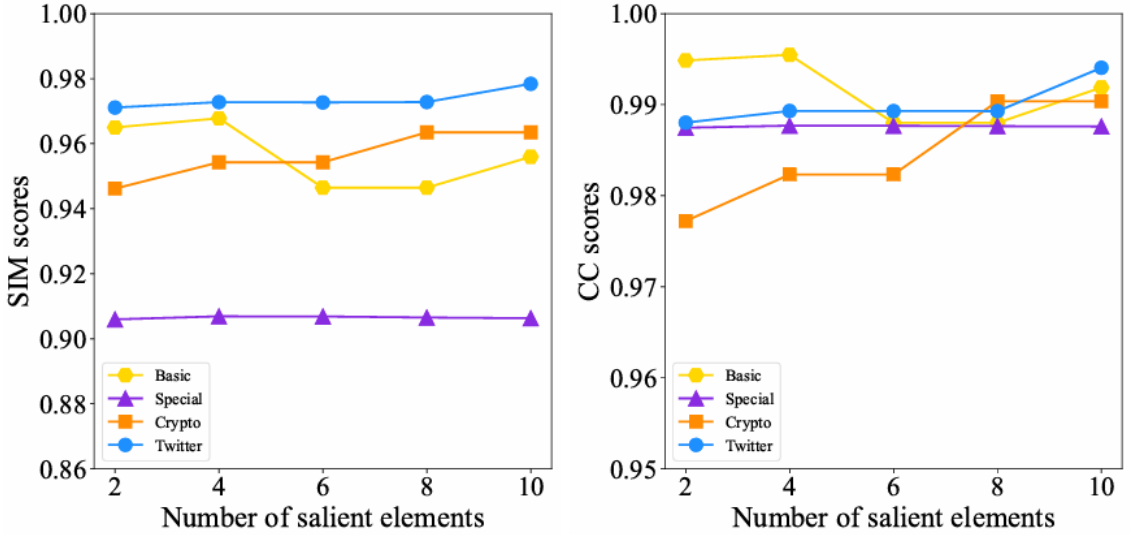
NUMBER OF SALIENT ELEMENTS AND SIM / CC

- SIM and CC scores show only slight changes or small increases as the number of salient elements rises.



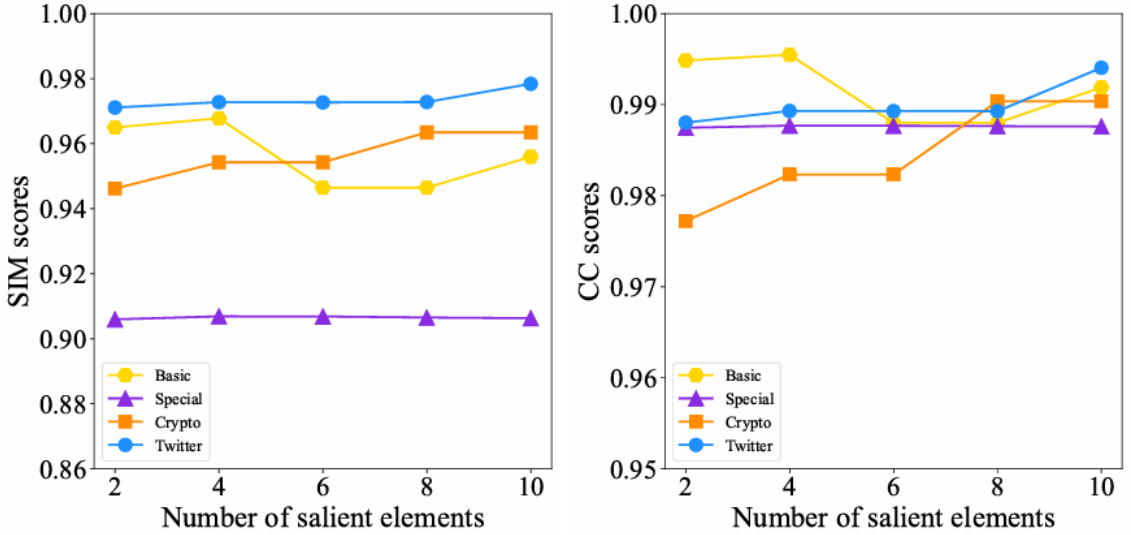
NUMBER OF SALIENT ELEMENTS AND SIM / CC

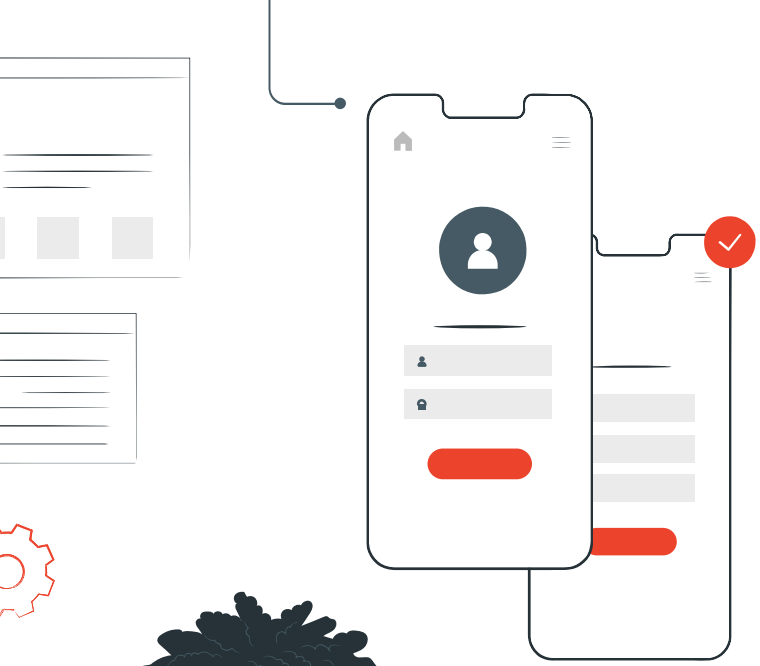
- The target levels of salient elements typically decrease less significantly compared to regular elements.



NUMBER OF SALIENT ELEMENTS AND SIM / CC

- As the number of salient elements increases, the guidance difference during power-saving layout generation grows more moderately.





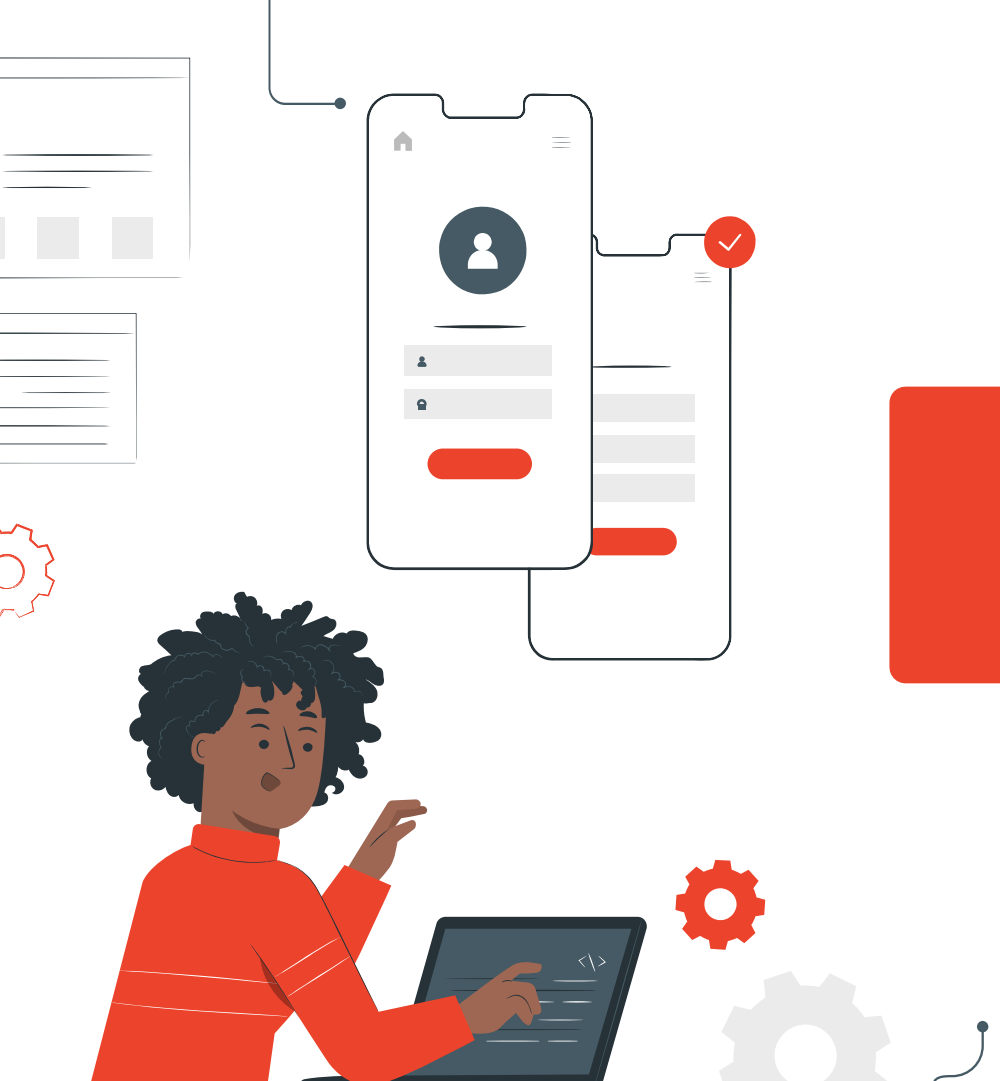
05

CONCLUDING

CONCLUDING

- Our design offers a new approach to help UI designers reduce power consumption on OLED displays.
- It achieves a **3%** to **41%** reduction in power consumption while maintaining UI guidance across mobile applications.
- By adjusting UI element colors, our design optimizes power savings while preserving both global and local UI guidance.

Thanks for listening !



Q&A