Chameleon: A Color-Adaptive Web Browser for Mobile OLED Displays

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Rice University

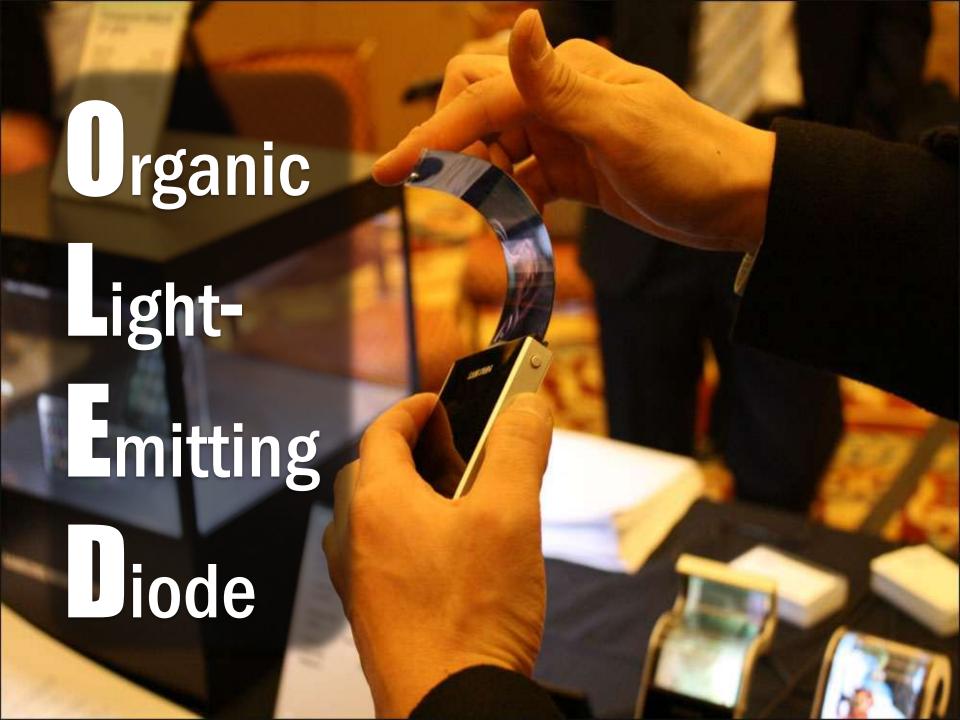


While last unplugged for 1h 27m 17s



ISINAN is a major power consumer in a smartphone

A. Carroll, "A analysis of power consumption in a smartphone," 2010

















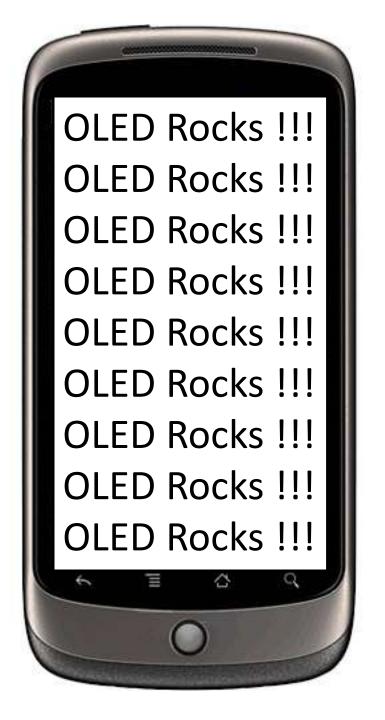












Power = 2.0W

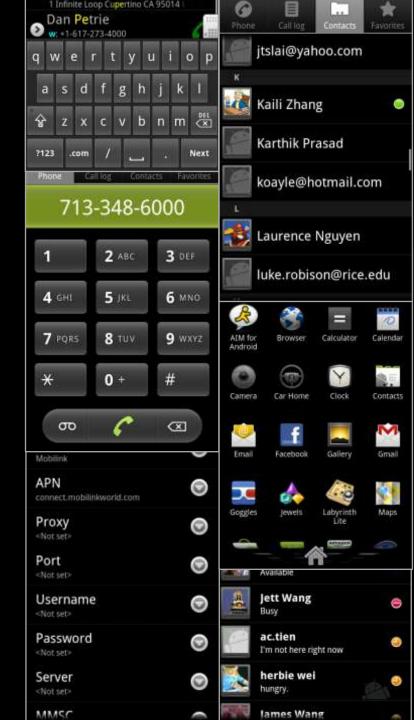


OLED Rocks !!! **OLED Rocks** !!! **OLED Rocks!!! OLED Rocks** !!! OLED Rocks !!! **OLED Rocks!!! OLED Rocks** !!! **OLED Rocks** !!! **OLED Rocks** !!!

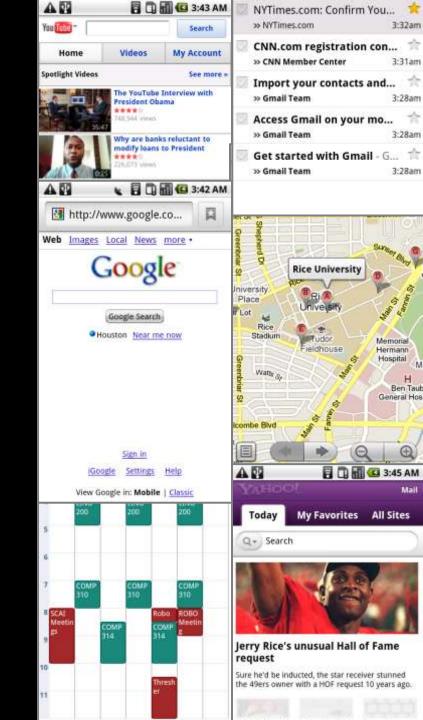
Power = 0.5W



An OLED-friendly theme works for GUIS



but not for Contents



65% of the contents

in the web are White



CIN

Ender Hom Divise Boar it (Bill) the Copyline and pulse of Figure Stice HONEVBAKED

LiveLab: A field study (25 users; 12 months)



LATEST NEWS

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Democratic leader Nancy Pelosi said Anthony...

Vancouver police blame Stanley Cup riots on anarchists
Where will new boss take al Qaeda?
Greek PM That Save go Trame For Identicis and ange of Color of Co

US

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- Giffords released from hospital; will continue outpatient therapy
- U.S. counterterrorism official: Zawahiri now leader of al Qaeda

WORLD

- Libyan rebels say captured cell phone videos show rape, torture
- Al-Zawahiri appointed al Qaeda's new leader, jihadist websites say
- · World outrage boils over Syrian crisis



Web Design solves the problem?

50% of the webpages visited by iPhone users are

Non-Mobile

Max: 70%

Min: 20%

Median: 50%

LiveLab: A field study (25 users; 12 months)

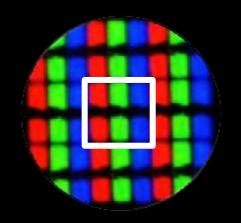




Generate Device Specific OLED Power Model

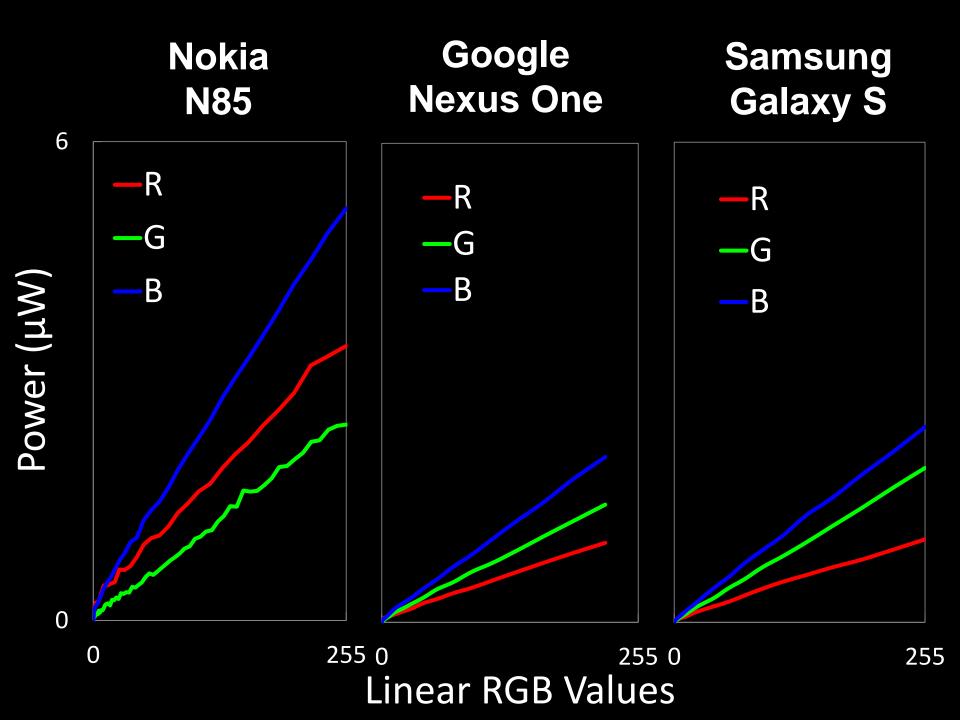
Single pixel i

$$P_i = a \cdot R_i + b \cdot G_i + c \cdot B_i$$



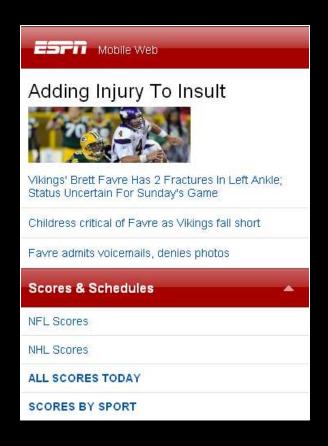
A display with N pixels

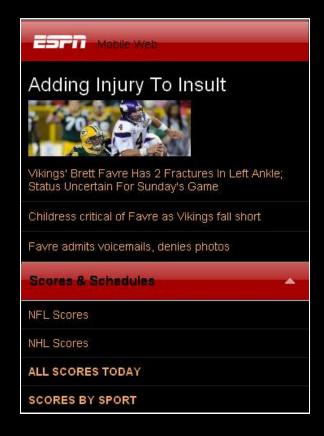
$$P = \sum_{i=1}^{N} P_{i} = \sum_{j=1}^{N} (a \cdot R_{j} + b \cdot G_{j} + c \cdot B_{j})$$



Treat GUI Objects and Images Differently

GUI Objects vs. Images



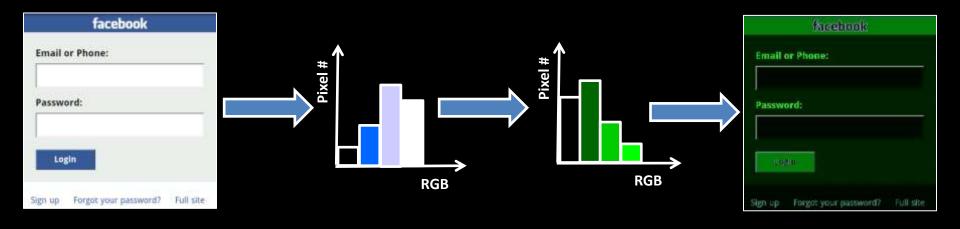


Color Transformation of GUI Objects

Color Counting

Color Mapping

Color Painting



Color Transformation of Images





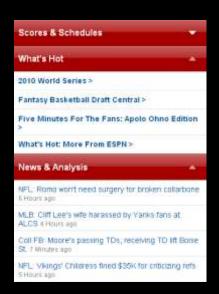


Keep Color Consistency for Each Website

Color Consistency per Website

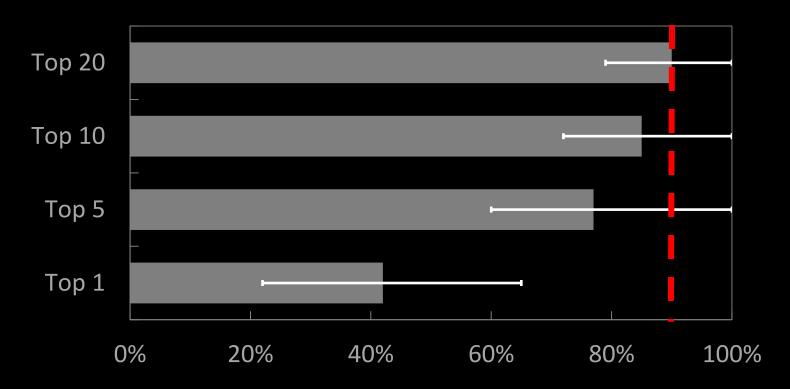








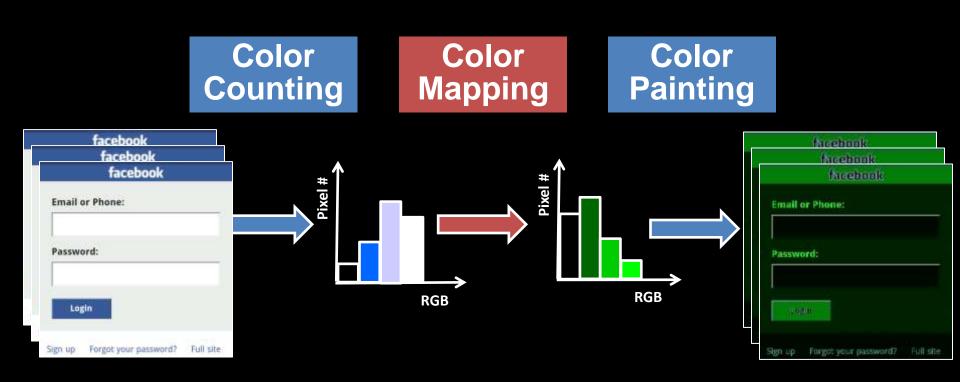
TOP 20 websites contribute 90% of the webpages visited by each user



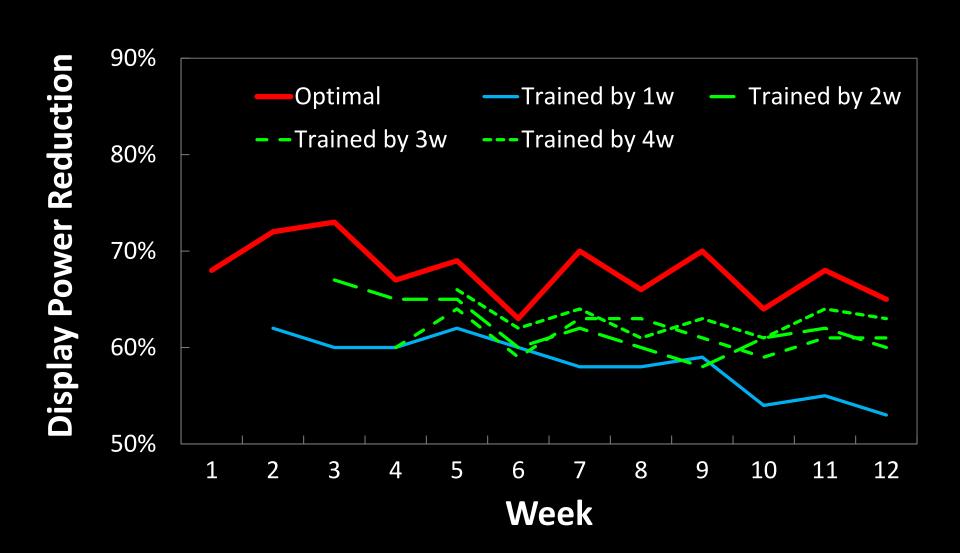
Average % of usage (with Max and Min) of all users

Calculate Color Maps Offline

Color Transformation of GUI Objects



2 Weeks of training work for 3 Months

































Give User Options

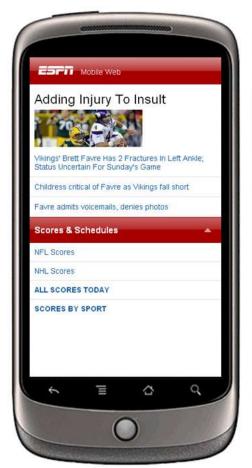


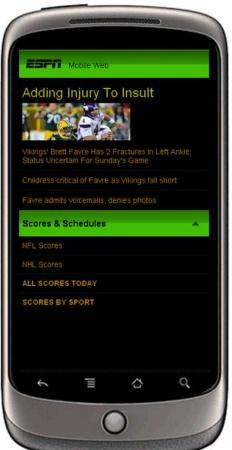










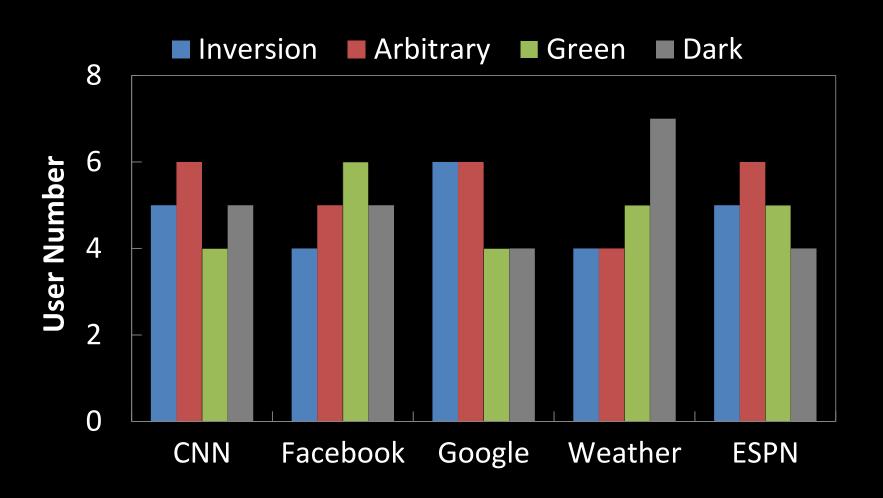




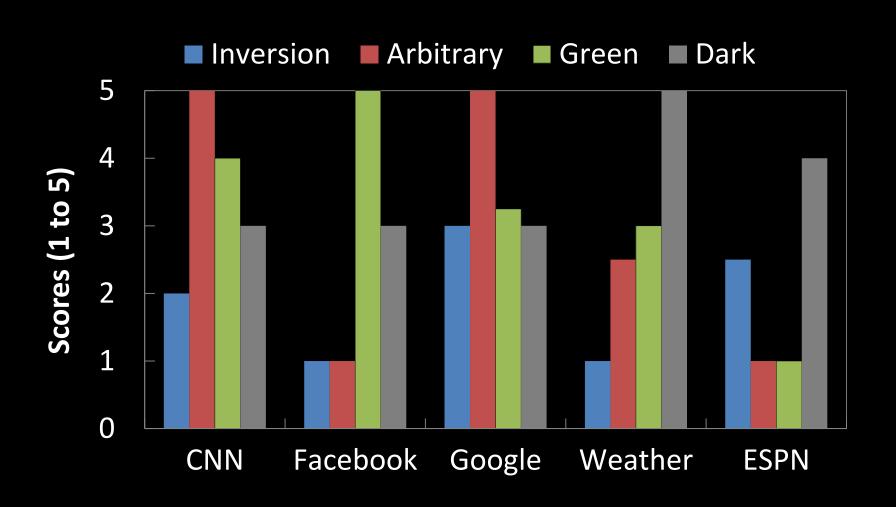
20 Participants

COFFI Mobile Web	ESFI Wale Web	ESPT Mode Web	ESPN Make Web	ESPN Mobile Web
Adding Injury To Insult Vikings' Brett Favre Has 2 Fractures in Left Ankle, Stanus Uncertain For Sunday's Game Chitchesis critical of Favre as Vikings fall short Favre admits vocemals, denies photos	Adding Injury To Insult Vikings Britt Favre Has 2 Fractures in Left Arkle, Status Uncertain For Sunday's Game Chitches critical of Favre as Vikings fall short Favre admits voccensals, denies photos	Adding Injury To Insult Vilongs' Brett Favre Has 2 Fractures in Left Ankle, Status Uncertain For Sunday's Game Childress critical of Favre as Vikings fall abort Favre admits voicemails, denies photos	Adding Injury To Insult Vikings' Brett Favre Has 2 Fractures in Left Arikle, Status Uncertain For Standay's Game Childress critical of Favre as Vikings fall short Favre admits voicemals, déries photus	Adding Injury To Insult Vivings' Beett Favre Has 2 Fractures in Left Ankle. Sliefus Graentan For Sunday's Game Childress-critical of Pavre as Vivings fall short. Favre admits vocemals, denies photos
Scores & Schedules	Scores & Schedules	Scores & Schedules	Scores & Schedules	Scores & Schedules
NFL Scores	NFL Scores	NFL Scores	NFL Scores	NFL Stores
NHL Scores	NHL Scores	NHL Scores	NHL Scores	NHL Scores
ALL SCORES TODAY	ALL SCORES TODAY	ALL SCORES TODAY	ALL SCORES TODAY	ALL SCORES TODAY
SCORES BY SPORT	SCORES BY SPORT	SCORES BY SPORT	SCORES BY SPORT	SCORES BY SPORT
Original	Dark R' = λ R G' = λ G B' = λ B 125%	Green $R' = \lambda_R R$ $G' = \lambda_G G$ $B' = \lambda_B B$ 434%	Arbitrary R' = R* G' = G* B' = B* 172%	Inversion R'= λ(1-R) G'= λ(1-G) B'= λ(1-B) 166%

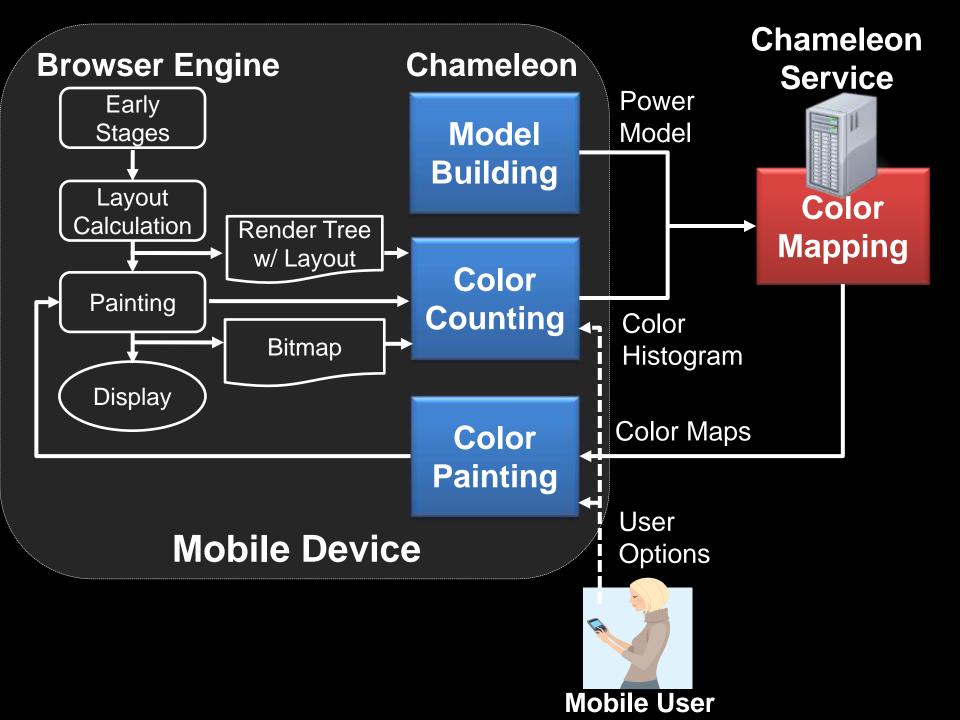
Different users prefer **different** transformations for a website



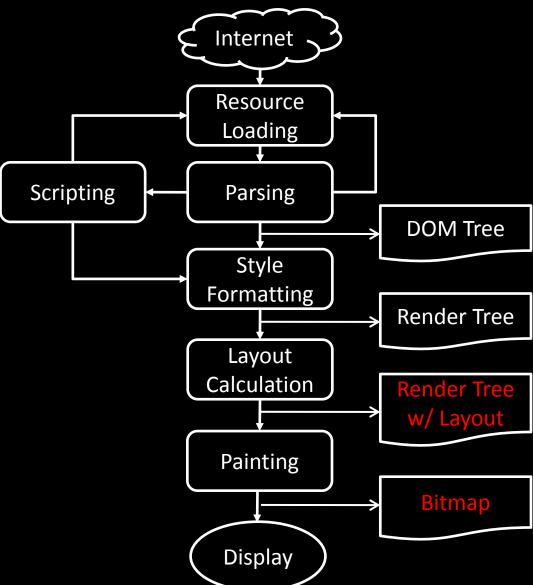
Even the *same* user may favor *different* color transformations for *different* websites



- Generate Device Specific OLED Power Model
- Treat GUI Objects and Images Differently
- **Keep Color Consistency**for Each Website
- Calculate Color Maps
 Offline
- **Give User Options**



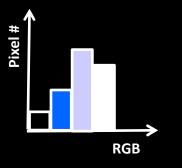
Color Counting





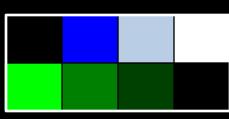
Mapping Optimization

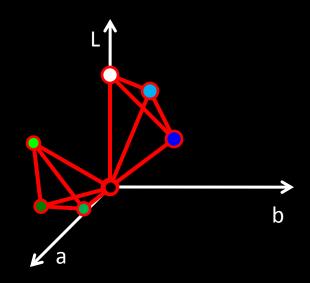
Input:



Output:

RGB R'G'B'





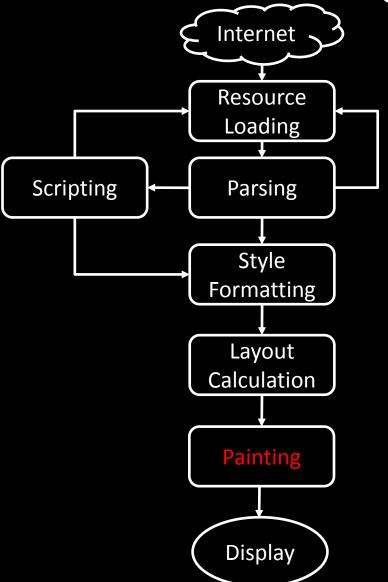
- Algorithm
 - Arbitrary

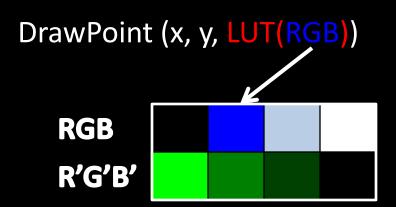
min Power

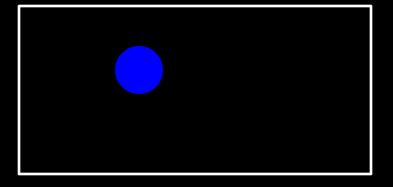
s.t. for any i, j

 $\Delta E ((L_i', a_i', b_i'), (L_j', a_j', b_j')) = \lambda \cdot \Delta E ((L_i, a_i, b_i), (L_j, a_j, b_j))$

Painting GUI Objects







Implementation

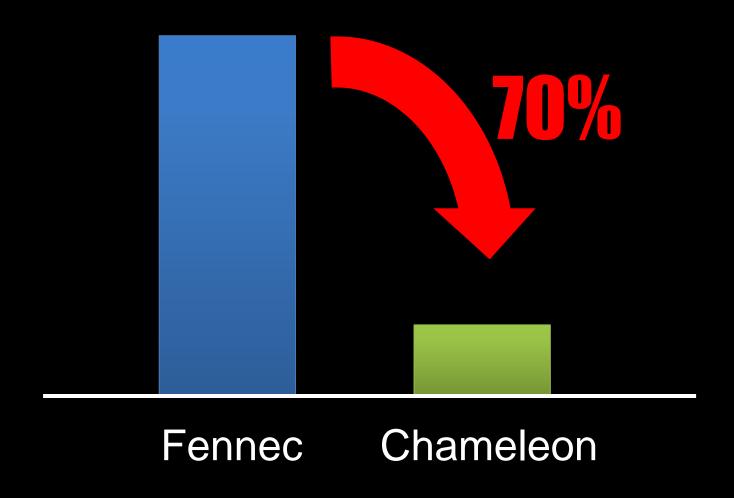
Fennec





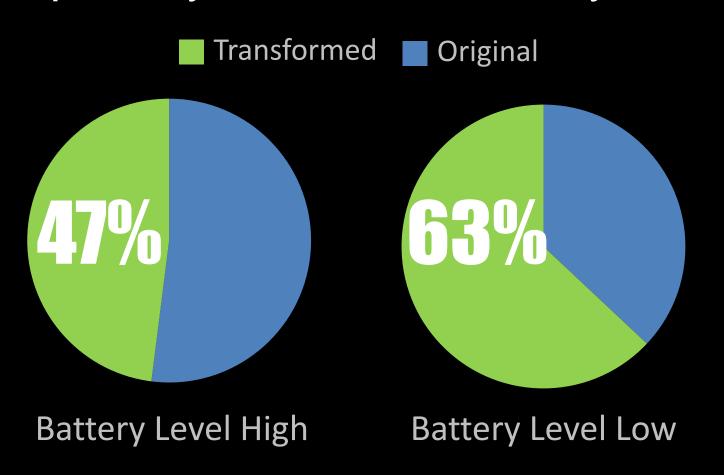


Display Power Consumption





Transformation is **Well Accepted** especially with a **LOW** battery level



Summary

- Color transformation is beneficial: 40%
 system power reduction for web browsing
- Color transformation is well accepted by users if performed properly
- Chameleon tremendously benefited from studying users