Modelling smartphone use

Vassilis Kostakos University of Melbourne

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Summary of techniques

- V. Kostakos, D. Ferreira, J. Goncalves, S. Hosio. 2016. "Modelling Smartphone Usage: A Markov State Transition Model", Proc. International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp), pp. 486-497.
- S. L. Jones, D. Ferreira, S. Hosio, J. Goncalves, V. Kostakos. 2015. "Revisitation Analysis of Smartphone App Use", Proc. International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp), pp. 1197-1208



Motivation

- Model smartphone use
- Make predictions about next "screen event"
- In realtime and ongoing





Markov modeling (variant)

- Probability of transitioning to a "state"
 - Given current state
 - Given elapsed time

Android Event	Description
0: Off	Power to the screen has stopped
l : On	Power to the screen has been activated
2: Lock	Screen locked (to avoid accidental input)
3: Unlock	Screen unlocked (input is enabled)



Method

- Re-analyse an existing dataset
 - 271,832 screen events
 - 90 days
 - n=218
 - Securacy: An Empirical Investigation of Android Applications' Network Usage, Privacy and Security (WiSec 2015)
- Validate with another dataset
 - 34,169 screen events
 - 30 days
 - n=17

- A Systematic Assessment of Smartphone Usage Gaps. (CHI 2016)



Results

To

		0: Off	1: On	2: Lock	3: Unlock
	0: Off	0.50%	33.03%	59.4%	7.05%
From	1: On	45.32%	2.03%	0	52.64%
	2: Lock	2.83%	95.64%	0	1.53%
	3: Unlock	80.5%	13.58%	0	5.92%















Account for context

- Day & time
- Battery level
- User "type"



Context: day & time













Context: battery level





Context: user "type"







OS can "Interrogate" the model

- How much time do we spend at each state?
- Starting in state 3, how much time (on average) does it take to reach either state 2 or 1?
- If the user turns on the phone (state 1), what is the probability that the phone remains in that state for 20 seconds?
 - For 120 seconds?
 - How does this change with context?



A worked example

• If we arrive to state I (screen ON), what is the probability that we are still in state I after 20 seconds?

= I - (
 probability we move to state 0 in less than 20 seconds +
 probability we move to state 2 in less than 20 seconds +
 probability we move to state 3 in less than 20 seconds
)







= I - (

0.4532 * (integral 0<t<20 for I→0) + 0 * (integral 0<t<20 for I→2) + 0.5264 * (integral 0<t<20 for I→3)



= I - (0.4532 * 0.6659034 + 0 + 0.5264 * 0.9705692)

= 0.187 i.e. 18.7%



Hence:	Model	Dataset
• Staying in state I for at least 20 se	c: 18.7%	10.5%
• For I20 sec:	6.9%	4.5%
 For 20 sec & battery > 75%: 	19.0%	10.9%
 For 20 sec & battery < 25%: 	17.7%	10.8%
• For 20 sec & 2pm:	17.5%	10.8%
• For 20 sec & 4am:	18.4%	6.6%

Error (RMSE) = 7.8%



Revisitation analysis: Do smartphones create habits?



We built an app and deployed to an appstore. The app collects data.







Differences in launching



Y-axis is LOGARITHMIC!



Histograms per user





Patterns emerge (users)





Histograms per app





Patterns emerge (apps)

Cluster	Description	Centroid	Example Apps	Cluster Size
Label		Revisitation Curve		(# Apps)
F1	Fast		Google Play Store, Facebook Messenger, InoReader, Chrome Beta, BlackBerry Messenger, Reddit, Okcupid	32 (13%)
F2	Fast	\sim	Chrome, Whatsapp, Facebook, Google Hangouts, SMS/MMS, Viber, Youtube, Contacts+, Google Maps, Firefox, Spotify, Skype, Snapchat, Xperia Conversations, Line, Reddit News, Telegram Messenger, Music, Falcon Pro	82 (33%)
M1	Medium	~~~	Phone, Gmail, Contacts, Email, Dialer, Clash of Clans, Instagram, Outlook, Yahoo Mail, Opera Browser	47 (19%)
S 1	Slow	$\sim \sim \sim$	Gallery 3D, Calendar, Camera, Twitter, Calculator, Clean Master (Speed Booster) Runkeeper Pro, Flipboard, Google Play Services, Mobile Bank, Mobile Weather, Flickr, Google Doc Editor, Tumblr, Quick Office, Google Translate	30 (12%)
82	Slow	$\sim \land$	Settings, Desk Clock, Organiser, Tinder, Plants vs. Zombies 2, Clash of Lords, Titanium Backup, Hot or Not, Control Panel, Candy Crush Saga, Castle Clash	40 (16%)
HI	Hybrid	\sim	Evernote, Google+, Google Docs, MusicBox, Adobe Reader, 9gag, Video Player, Meo Remote, Waze, Dictionary, Opera Mini	21 (8%)



Compare to Web revisitaton (2000's)

Cluster	Centroid	Description	Corresponding cluster group descriptions from Adar <i>et al.</i> [1]
Fast (F1,F2)		Instant Messaging, Browser, Social Media	Hub & Spoke, Shopping & Reference, Auto refresh, Fast monitoring, Pornography & Spam.
Medium (M1)	\sim	Email and Phone Communication	Popular homepages, Communication, .edu domain, browser homepages.
Slow (S1,S2)	$\sim\sim$	Utilities, Multimedia, Health and Fitness, Games, Dating, Phone Settings	Entry pages, Weekend activity, Search engines used for Revisitation, Child-oriented content, Software updates
Hybrid (H1)	\sim	Documents, Notes, Video, Satnav	Popular but infrequently used, Entertainment & Hobbies, Combined Fast & Slow.



Similar patterns. What does this mean?

Do phones create habits?







Prof. <u>Vassilis Kostakos</u> vassilis.kostakos@unimelb.edu.au

School of Computing and Information Systems University of Melbourne

