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UbiComp/ISWC 2019: A Post-Conference Summary Report

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Abstract—The 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp 2019) took place from 9–13 September in London, U.K., colocated with the International Symposium on Wearable Computers. Meanwhile, the second UK Research Symposium on Mobile, Wearable, and Ubiquitous Systems (MobiUK'19) took place between 1st and 2nd of July in Oxford, U.K.

■ **IN THIS CONFERENCES** column, we bring you not one but two recent events. The 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp 2019) took place from 9–13 September in London, U.K., colocated with the International Symposium on Wearable Computers (ISWC 2019).

Held in London this year, they attracted more than 680 participants and highlighted a total of 210 papers that featured a variety of recent technologies ranging from theoretical contributions to practical applications on ubiquitous and pervasive computing. Also in the South of England this summer was the 2nd UK Research Symposium on Mobile, Wearable, and Ubiquitous Systems.

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UbiComp/ISWC: September 2019, London

UbiComp/ISWC 2019 was initiated with two keynotes. Marta Kwiatkowska, a professor at the University of Oxford, presented the first keynote on modeling and personalization techniques and their roles in many applications such as medical devices, biometric security, and self-driving cars. In the second keynote, Lama Nachman, an Intel Fellow and the Director of Anticipatory Computing Lab in Intel Labs, discussed assistive computing, their experiences developing technologies for Stephen Hawking, and challenges in utilizing those technologies.

With 36 presentation sessions, workshops, posters, demos, and design exhibitions, UbiComp/ISWC 2019 covered a range of topics in the area of mobile, ubiquitous, wearable computing. In this paper, we describe exciting work in 1) health, 2) privacy, 3) haptics and kinetics, 4) user behaviors and mobile applications, 5) localization, 6) work, family, and society, 7) wearables, and 8) interaction paradigms.

Health

A significant focus at UbiComp/ISWC this year was the impact and implications of computing for improving the physical and mental health of individuals, with particular emphasis placed on mental health. Indeed, one of the recipients of the distinguished paper award, “Assisted Medication Management in Elderly Care Using Miniaturised Near-Infrared Spectroscopy” by Simon Klakegg at the University of Oulu, showed that their system could sort pills with high prediction accuracy, providing high impact in the future. Two well-attended workshops were conducted during the first two days of UbiComp/ISWC 2019 to discuss state of the art research on detecting, preventing, and intervening in the mental health and well being of individuals. We cover one of these workshops here, together with a summary of three sessions from the main conference program.

The focus of the Mental Health and Well-being: Sensing and Intervention workshop was to discuss the issues and opportunities around using ubiquitous computing technologies for sensing and intervention in the mental health domain. Participants discussed projects such as measuring the effect of listening to music on

stress regulation and investigating the use of smart speakers for mental health monitoring. A common challenge identified by workshop participants was gathering accurate ground truth data, given that individuals or clinicians subjectively evaluate mental states. Other challenges in this space include explaining the output of machine learning models to clinicians, translating short research deployments into real-world impact via longer-term deployments or commercialization, implementing appropriate data privacy controls, and reappropriating commercial devices for research purposes. J. Simmons of the Social and Affective Neuroscience Program at the National Institute of Mental Health delivered the keynote address, discussing the priorities of mental health researchers and professionals and opportunities for collaboration with the ubiquitous computing research community.

Andrew Campbell (Dartmouth College) chaired the Mental Health session in the main conference programme. He opened the session by mentioning that UbiComp/ISWC research in mental health has advanced significantly over the past ten years, but has a long way to go before people can use it in their everyday lives. There was a common theme in detecting mental health conditions. These included stress, depression, and mood instability using unique features extracted from mobile data and the use of novel machine learning models. In addition, Wasifur Rahman (University of Rochester) presented interesting work on the diagnosis of posttraumatic stress disorder in refugees from Bangladesh using electroencephalogram signals.

The Mobile Health session chaired by Monica Tentori from CICESE focused predominantly on how interventions for healthcare can be delivered through mobile phones. Work presented by Woohyeok Choi (KAIST) and Peng Liao (University of Michigan) focused on unique ways of performing just-in-time interventions for health. Chia-Fang Chung from the Indiana University Bloomington discussed their work on the design of unique and personalized photo diaries to help individuals achieve their eating goals.

Presenters in the Wearable Health Sensing session chaired by Jakob Bardram from the Technical University of Denmark discussed using wearable sensors in health contexts. The majority of these

135 projects used machine learning to detect patterns
136 in wearable sensor data that are associated with
137 clinically relevant activities and symptoms. Cath-
138 erine Tong from the University of Oxford dis-
139 cussed using a model to predict the fatigue and
140 health status of Multiple Sclerosis patients using
141 connected wellness devices, using weekly ques-
142 tionnaires as ground truth. The patients were able
143 to use the devices as much or as little as they
144 wanted to, which mimicked real-world usage but
145 led to challenges in accounting for missing data
146 during analysis. B. Teja Gullapalli from the Uni-
147 versity of Massachusetts Amherst presented a
148 unique in-lab study investigating the relationship
149 between cocaine-induced subjective states such
150 as craving and electrocardiogram and respiratory
151 features sensed via a chest band.

152 Privacy

153 With increasing advances in ubiquitous com-
154 puting, privacy must be taken into consider-
155 ation. This year at UbiComp/ISWC, researchers
156 developed new systems and tools for enhancing
157 individuals' privacy, investigated new ways of
158 identifying different privacy attacks, and discov-
159 ered novel authentication methods.

160 Researchers highlighted the importance of
161 creating more transparent, user-centric privacy-
162 friendly applications. Xiaolei Wang from the
163 National University of Defense Technology pre-
164 sented LeakDoctor, which determines if an
165 application's privacy disclosure is essential for
166 its functionality and, thus, protects users from
167 unnecessarily disclosing sensitive data. More-
168 over, MobiPurpose presented by Haojian Jin
169 from the Carnegie Mellon University (CMU) sys-
170 tematically classifies an applications' data collec-
171 tion purposes to help users understand why an
172 application might want to obtain their private
173 information. Finally, Mengwei Xu from Peking
174 University presented DeepType, a paradigm that
175 allows text input personalization to be performed
176 privately on a user's local device, rather than on
177 the cloud.

178 Identifying new ways that ubiquitous technol-
179 ogies can pose harmful privacy threats is critical
180 for understanding our community's future direc-
181 tions with designing privacy-preserving ubiqui-
182 tous systems. Tyler Giallanza (Darwin Deason
183 Institute for Cybersecurity) highlighted potential

privacy threats for keyboard snooping on mobile
phones. Swadhin Pradhan (University of Texas at
Austin) presented REVOLT, a system that detects
voice-replay privacy attacks on users of voice-
based personal assistant devices. Likewise, Anin-
dya Maiti (University of Texas at San Antonio)
investigated how users' media consumption
could be inferred through analyzing multimedia
visualization techniques of smart lights.

Using biometrics for authentication was a pre-
dominant topic at this year's conference, as sev-
eral systems utilized various biological factors
for validating an individuals' identity. Daniel Hin-
tze (Johannes Kepler University Linz) presented
CORMORANT, a mobile authentication paradigm
that incorporates biological and physiological
metrics such as gait, voice, face, and keystroke
dynamics to determine a user's identity. Other
creative biological techniques for authentication
included AcousticID, a system that uses gait
information from acoustic signals for identifica-
tion, and EarEcho, a wearable authentication
device that integrates information from a user's
ear canal echo.

Haptics and Kinetics

The Haptics and Kinetics session showcased
some novel interaction methods. A work of Erik
Pescara (Karlsruhe Institute of Technology) on
passive haptic learning described the learning of
morse code without voluntary involvement of
attention, focus, or motivation through a wear-
able haptic interface. Lawrence H. Kim (Stanford
University) discussed a Vibration, Pressure,
Shear (VPS) tactile display on the arm that can
transfer the tactile information using a combina-
tion of vibration, pressure, and shear. Granit
Luzhnica (Know Center) explained his latest
work on boosting word recognition for vibrotac-
tile skin reading through multiple user training
methods. A novel input, output, and construction
methods for custom fabrication of room-scale
deployable pneumatic structures are given by
Saiganesh Swaminathan at CMU. A work of Esther
W. Foo (University of Minnesota) on garment-
based dynamic compression discussed the user
experiences of novel haptic applications. Keni-
chiro Shirota (Keio University Graduate School of
Media Design) exhibited his research on explor-
ing the shape change of pinna (i.e., the visible

233	part of the ear) for perception and illusion of	where, and what apps are used and then predict	282
234	sound direction change.	future app usage.	283
235	User Behaviors and Mobile Applications	Localization	284
236	As the ubiquity of smartphones increases, a	Two sessions focused exclusively on localiza-	285
237	large amount of data regarding user behaviors in	tion were held at UbiComp/ISWC this year, with	286
238	both online and offline platforms has become	considerable attention paid to blending various	287
239	available for the research community. UbiComp/	technologies into more accurate and reliable	288
240	ISWC 2019 featured a variety of novel research	localization apparatus.	289
241	works, which investigate various user behaviors	Tao Gu (Royal Melbourne Institute of Tech-	290
242	such as user's geographical mobility to mobile	nology) chaired the localization techniques ses-	291
243	application (app) usage patterns.	sion, which covered contemporary approaches	292
244	One research direction is to understand	to localization in a variety of contexts. Xinyu	293
245	users' navigational behaviors, which is vital to a	Tong (Shanghai Jiao Tong University) presented	294
246	large number of applications, ranging from effec-	insights in improving localization efficiency for	295
247	tive recommendations to urban service planning.	batch localization mechanisms to face the change	296
248	Amin Sadri from the Royal Melbourne Institute of	of assumptions for the new paradigm. Indoor	297
249	Technology presented a new trajectory predic-	localization attracted much attention. Xuehan Ye	298
250	tion problem, to predict the sequence of future	(Renmin University of China) proposed a learning	299
251	locations (e.g., a trajectory in the afternoon)	transition model for the floor mapping, while	300
252	based on given historical data (e.g., a trajectory	Huatao Xu (Shanghai Jiao Tong University) pre-	301
253	in the morning). Yan Zhang (Peking University)	sented a holography-based approach to the	302
254	studied an interesting problem of route predic-	radio-frequency identification (RFID) tagging and	303
255	tion for instant delivery and developed a design,	position estimation method. Huijie Chen (Beijing	304
256	which reduces the rate of the deliveries not fin-	Institute of Technology) explored the crowd-	305
257	ished in time by a huge margin. In addition,	sourcing approach toward floorplanning as well	306
258	Young D. Kwon from the Hong Kong University of	as extracting both audio and inertial data.	307
259	Science and Technology investigated users'	Christos Efstratiou from the University of Kent	308
260	reviewing behaviors exhibited both online and	chaired a session dedicated to optical approaches	309
261	offline from which he proposed various features	toward efficient localization. The session, localiza-	310
262	and significantly improved the performance of	tion with vision and light, consisted of four presen-	311
263	the churn prediction problem.	tations discussing methods to combine light	312
264	Studying how we can utilize large-scale data	sensors, RFID, and computer vision for more	313
265	of users' app usages provides a fruitful research	accurate localization. Lin Yang from Noah's Ark	314
266	direction, which can enhance our understanding	Lab presented new sensors, which employ high-	315
267	of users' behaviors. Mohammed Khwaja (Impe-	frequency modulation for obtaining visible light	316
268	rial College London) improved machine learning-	positions, with a deep neural network model	317
269	based personality modeling by collecting mobile	for filtering the "invisible visual features" from	318
270	sensing data and self-reported Big Five traits	the light. Zhongquin Wang from the University of	319
271	from 166 participants in five different countries	Technology Sydney and Jingao Xu from the	320
272	for three weeks. Jaejeung Kim (KAIST) investi-	Tsinghua University approached indoor localiza-	321
273	gated the effects and user experiences of differ-	tion through blending computer vision and RFID	322
274	ent intensities of restrictive interventions (e.g.,	tagging for increased precision, while Huanhuan	323
275	locking a user from using a smartphone). Zhen	Zhang from the Beijing University of Posts and	324
276	Tu (Tsinghua University) examined the feasibil-	Telecommunications developed a model for the	325
277	ity of making personalized location recommen-	recognition of unmodified lights.	326
278	dation by learning user interest and location	Work, Family, and Society	327
279	features from app usage data. Likewise, Huang-	UbiComp/ISWC has become the forefront of	328
280	dong Wang (also Tsinghua University) proposed	research within pervasive sensing and actuation	329
281	a new Bayesian mixture model to capture when,		

330 for alleviating productivity and accessibility in
331 the workplace at home and within the society
332 we live. This year's edition featured results from
333 several important studies of integrating the
334 Internet of Things (IoT), wearables, and interac-
335 tion with mobile devices into one's daily life—
336 and conclusively increasing the quality of life for
337 relevant stakeholders.

338 In the UbiComp at Work session, Shayan
339 Mirjafari at (Dartmouth College) discussed the
340 methods of utilizing mobile sensing data from
341 smartphones, wearables, and beacons to help
342 study behavioral differences in low and high
343 performing individuals in the workplace for in-
344 time assessment and guidance in the work-
345 place. Furthermore, Utku Günay Acer (Nokia
346 Bell Labs) presented results from a real-world
347 trial of 10 Belgian post employees that utilized
348 wearable-based intervention to enhance the
349 spatial coverage, response accuracy, and incre-
350 ease workers' engagement with crowdsour-
351 cing tasks. Finally, Mohit Jain (University of
352 Washington) presented the work on designing
353 conversational agents for user populations
354 with limited literacy and technology experi-
355 ence, with results from an evaluative study
356 with 34 farmers in India.

357 Hyosun Kwon from the University of Notting-
358 ham presented work on Connected Shower, an
359 IoT device that captures water flow, tempera-
360 ture, and shower-head movement. The study
361 concluded that sharing intimate data with
362 service providers was acceptable if the data
363 were sufficiently abstract and anonymized. The
364 research threw light upon the challenges in the
365 design of trustworthy data-driven IoT systems,
366 and what needed to be warranted to be both
367 acceptable into activities of our daily living.
368 Anna Wojciechowska from Ben Gurion Univer-
369 sity of the Negev presented a model of how peo-
370 ple understand drones based on their design
371 and proposed a set of design guidelines for
372 future personal drones. Finally, Timo Jakobi
373 from the University of Siegen discussed a design
374 case study of IoT at home, where the author
375 equipped 12 households with do-it-yourself
376 (DIY) smarthome systems for two years and
377 studied participants' strategies for maintaining
378 system awareness, from learning about its work-
379 ings to monitoring its behavior.

A work of Ying-Yu Chen (University of Wash-
ington) on adoption barriers for technology for
family mealtime found that parents prefer
screen-based technology over voice interfaces
and smart objects because parents perceive the
latter two systems to intrude on their relation-
ship with children. Anastasia Kuzminykh (Uni-
versity of Waterloo) discussed results from a
multiphase study on a framework designed for
parents to monitor their toddlers and school-age
children. Concluding the Family and Technology
session, Chuang-Wen You at the (National Tai-
wan University) presented SoberComm, a mobile
support system that provides quantitative and
qualitative evidence that the system enhances
problem-solving skills and facilitates communi-
cation between alcohol-dependent patients and
their family members.

Wearables

Researchers in the UbiComp/ISWC focused
on developing and exploring new ways of using
wearables in many practical scenarios.

Researchers explored novel ways of interac-
tion with embedded e-textile sensors. Flex-
Touch, by Yuntao Wang (Tsinghua University),
is a technique that enables long-range touch
sensing for up to 4 m and object detection for
distances up to 2 m. Phyjama, presented by Ali
Kiaghadi (University of Massachusetts Amherst),
explores how textile sensors can be embedded
in loose-fitting clothing, such as sleepwear made
from cotton or silk fabric, to monitor users' car-
diac or respiratory rhythms. Similarly, Ruibo Liu
(Dartmouth College) investigated how soft, con-
ductive fabrics can infer joint rotational motion
for physical rehabilitation purposes.

Existing wearable fitness technologies can
make physical activity tracking in realistic sce-
narios difficult, and at times, inaccurate. Gino
Brunner from ETH Zurich explored this concept
in swimming by applying deep learning techni-
ques with a smartwatch for accurate lap counting
and style recognition in an authentic, uncon-
trolled environment. Likewise, Xiaonan Guo from
Indiana University–Purdue University Indianapo-
lis extended fitness trackers beyond the wearable
device through developing a personalized fitness
assistant system with only using WiFi. On a
macro-level, Jessica R. Cauchard from Ben Gurion

429 University of the Negev presented an analysis of
430 how different tactile and visual feedback in
431 sports fitness technologies affected users behav-
432 ior for future design implications.

433 Interaction Paradigms

434 Papers on new interaction paradigms mainly
435 focused on new input methods for wearables and
436 smartphones. Lik Hang Lee (Hong Kong Univer-
437 sity of Science and Technology) presented a novel
438 one-handed thumb-to-finger input method for
439 augmented reality head-worn computers, such as
440 smart glasses while achieving better results than
441 existing thumb-to-finger solutions. Zhican Yang at
442 Tsinghua University explored a new way for acti-
443 vating voice input on smartphones by avoiding
444 the need to press a button or using a wake word
445 for activation. He presented ProxiTalk, a method
446 that recognizes the user's intention when bring-
447 ing the phone close to the mouth to activate
448 speech input while only using in-built smartphone
449 sensors. Moreover, Rushil Khurana (Carnegie
450 Mellon University) proposed the concept of a
451 detachable smartwatch that can be used as a
452 wearable device depending on the context, such
453 as for navigation when biking, game controller, or
454 blindspot detector inside of a car. Juyoung Lee
455 (KAIST) presented SelfSync, a concept of having
456 the user move two body parts in synchrony to ini-
457 tiate communication with their computer and
458 suggests two synchronous gestures by using
459 wrists, leg, and head movements.

460 Looking Forward

461 Next year's UbiComp/ISWC 2020 will be held
462 on 12–16 September 2020 in Cancun, Mexico. It
463 will again be multitrack and include a broad mul-
464 tidisciplinary program.

465 MobiUK: July 2019, Oxford

466 The 2nd UK Research Symposium on Mobile,
467 Wearable, and Ubiquitous Systems (MobiUK '19)
468 took place from the 1st to the 2nd July 2019 at
469 the Department of Computer Science, University
470 of Oxford, UK. This year's symposium attracted
471 81 participants and featured 28 extended abstr-
472 act submissions with subsequent presentations
473 from total of 37 authors from universities across
474 the U.K.

Invited Talks

475

476 Seven invited talks were given throughout the
477 symposium, covering a broad range of research
478 topics. First, Suman Banerjee from the University
479 of Wisconsin-Madison kicked-off MobiUK '19 with
480 a talk on "The Roaming Edge (in Smart Cities)," a
481 mobile sensing platform on the edge deploying
482 mobile sensors for transport analytics. Using
483 their moving sensing platform Trellis, he shared
484 how edge computing can cope with huge amounts
485 of data collected via sensors in and on buses.
486 Questions circulated around the challenges of
487 integrating a third-party application ecosystem
488 on the edge, the lack of situational awareness of
489 sensors, and with regards to ethics, security, and
490 privacy. Amanda Prorok from the University of
491 Cambridge showed cutting edge results from her
492 lab around trajectory planning for autonomous
493 robots. In "When Robots Hit the Road: New Chal-
494 lenges in Multi-Vehicle Coordination," she dis-
495 cussed the challenges of coordinating robots
496 including the creation of information flows for
497 control components, how to incorporate commu-
498 nication, and achieve consensus for assignments.
499 Prorok also talked about data obfuscation for
500 increased privacy using a geo-indistinguishability
501 approach. On the second day, Tanzeem Choud-
502 hury (Cornell University) gave the talk "Mindless
503 Computing: Designing Technologies to Subtly
504 Influence Behavior," which highlighted her lab's
505 efforts in integrating technology seamlessly into
506 our daily lives. For instance, dining plates with
507 RGB sensors change color based on the color of
508 food, influencing people to increase/decrease the
509 quantity of food they serve. Discussions revolved
510 around integrating environmental awareness into
511 these technologies and their system's long-term
512 effectiveness. The last invited talk by Romit
513 Choudhury from the University of Illinois at
514 Urbana Champaign was about multi-sensory
515 in-ear wearable computing devices, describing
516 new possibilities such as jaw motion or hollow
517 earphones for better ear-care. His team built a
518 prototype that moved the DSP outside of the
519 headphones so that it can listen to noise much
520 before it reaches the user's ear. They showed con-
521 siderable decrease in noise levels compared to
522 current Bose state-of-the-art headphones. The
523 talk led to various interesting discussions about
524 the future and challenges in building earable

525 devices, and the limitations of their current head-
526 phone model.

527 The remaining invited talks formed this year's
528 industry session in which some of the sponsors
529 shared new developments and projects with the
530 research community. First, Markus Hoffmann
531 from Nokia Bell Labs started his talk "Creating a
532 Reality Beyond the Real" by describing his vision
533 of a multisensory future, where use of technology
534 is innate in our natural lifestyle rather than being
535 a hindrance. In one such application, his team is
536 working with Alex Thomson, a British yachtsman,
537 to develop devices and a framework that can
538 understand the state of our physical and mental
539 well being without us having to actively interact
540 with the device. Participants hinted at potential
541 risks of integrated technologies collecting lots of
542 personal data, voicing privacy concerns, and
543 explored possible solutions, i.e., potential data
544 ownerships via government regulations or tech-
545 nology hierarchies. Andrew Mundy from ARM dis-
546 cussed challenges and opportunities of running
547 "Machine Learning on the Edge" in contrast to the
548 central cloud. He emphasized that running deep
549 neural net-based inferences on the edge are chal-
550 lenging due to its limited resources. The heteroge-
551 neity in edge infrastructure is another challenge
552 as most are owned by multiple manufacturers run-
553 ning their proprietary APIs. Mundy mentioned
554 that ARM is interested in leveraging the existing
555 frameworks like TensorFlow, PyTorch to build sol-
556 utions on top of it citing FixyNN as an example.
557 Finally, Justin Philips from Google talked about
558 "The Challenge of Continuous Heart Rate Monitor-
559 ing from Wearables," where he described the
560 mechanism used for monitoring the heart rate
561 measurement (HRM) using Photoplethysmograph
562 (PPG). The Google Fit platform has also integrated
563 other device sensors like Inertial Measurement
564 Unit with PPG to reduce the HRM error rate. The
565 talk led to lively follow-up discussions to under-
566 stand reasons of degradation in HRM quality,
567 range of degradation, and how would skin color
568 affect their technique?

569 Machine Learning

570 The presentations of the five paper sessions
571 spanned a range of domains and themes with
572 one major research trend around the theme of
573 machine learning (ML) clearly prominent.

With a total of nine long and two short presen-
574 tations, the theme of ML covered two sessions.
575 Two talks covered issues around developing on-
576 device deep learning with limited resources, e.g.,
577 memory constraint environments such as micro-
578 controllers and mobile devices. One was pre-
579 sented by Javier Fernández-Marqués *et al.* and
580 another by Valentin Radu. Other talks related to
581 ML covered analyzing audio sensors for social
582 sensing with the goal to identify speakers with
583 only one smartphone by compressing audio that
584 produces a compressed representation, which is
585 able to recognize voices of known and new speak-
586 ers. Applications envisioned by the researchers
587 support for autistic persons to analyze their
588 social interactions, but privacy issues still need
589 exploration. Privacy was also discussed in an
590 automatic data summarization methodology talk
591 by Manousakas *et al.* that combined Bayesian
592 coresets models and differential privacy to allow
593 for scalable data analysis and the reduction of
594 inference cost. Also using Bayesian models was
595 the team of Gudur *et al.* proposing their Active-
596 HARNet approach, which combines Bayesian
597 deep learning with human activity recognition
598 solving the issue of unlabeled data with only a
599 few data points. Finally, Haoyu Liu from Edin-
600 burgh University presented an investigation of
601 the security of Belkin Smart Home devices WeMo
602 finding an exploit that allows for WiFi passphrase
603 leakage making the devices vulnerable to phish-
604 ing attacks.
605

Security and Privacy 606

The session on security and privacy included
607 five talks: Dodson *et al.* conducted a longitudinal
608 study of 50 000 Internet-connected industry con-
609 trol systems (ICS) without access control intro-
610 ducing a model to fingerprint unsecured, Internet-
611 connected ICS (robotic arms, conveyor belts,
612 pulps, etc.). During the discussion, the authors
613 were asked if they know of tailored mass attacks,
614 but most are initiated on traditional ways, e.g.,
615 Stuxnet. Vasile *et al.* highlighted other security
616 issues around key authenticity in secure mobile
617 messaging. Problematising how key management
618 is not done by users alone, she explained how key
619 serves are vulnerable to ghost user attacks. Their
620 solution was an advanced notification system
621 that gathers more contextual information such as
622

623 employing goshopping to establish trust and con-
 624 firming keys automatically. Perez *et al.* explored if
 625 and how mobile devices can be traced and identi-
 626 fied via their electromagnetic emissions. They
 627 experimented with two kinds of attacks. First,
 628 internal (app-based) attacks in which approxi-
 629 mately ten data points were needed to identify
 630 single device with 98.9% accuracy. Second,
 631 external (proximity-based) attacks, which also
 632 resulted in the identification rate of single devices
 633 of 96.7%. Finally, N. Davies was talking about the
 634 design and implementation of an enhanced pri-
 635 vacy mediator approach to privacy protection in
 636 IoT-rich environments combining mobile technol-
 637 ogy and Cloudlets.

638 Sensing—Algorithms and Applications

639 In this session, four long and two short talks
 640 were presented. Zhang *et al.* developed an
 641 approach, SensorID, to calibrate smart device
 642 sensors without the danger of uniquely identify-
 643 ing a specific device. Based on Gain Matrix Esti-
 644 mation and the sensor outputs, their approach
 645 produces globally unique fingerprints for iOS
 646 devices. It was pleasing to see a demonstration
 647 of research impact in SensorID—Apple have
 648 adopted their suggestion of adding noise and
 649 have also removed sensor access by default in
 650 Mobile Safari. Ferlini *et al.* provided insights of
 651 their work with Nokia Bell Labs on Multimodal
 652 Learning algorithms which enables in-ear hearing
 653 devices to leverage multiple inputs such as audio,
 654 head movements, eye movements, and so forth.
 655 They provide a real-time solution in a resour-
 656 ce constrained environment in order to reduce
 657 the cocktail-party problem. Catherine Tong pre-
 658 sented their team’s work on ML to model the data
 659 from 198 Multiple Sclerosis (MS) patients’ con-
 660 nected health and wellness devices (smartwatch,
 661 weighing scale, sleep tracker) to predict patients
 662 self-reported fatigue and health state scores for
 663 six months. Their solution is based on an ensem-
 664 ble of modality-specific AdaBoost regressors,
 665 which handles the issues of multimodal and miss-
 666 ing data elegantly. Intarasirisawat *et al.* were tack-
 667 ling how to use game-based assessments for early
 668 detection of cognitive decline such as dementia.
 669 They integrated their solution into existing
 670 mobile games like Tetris, Fruit Ninja, and found
 671 that device touch (swipe speed, length) and

672 motion are significantly correlated with cognitive
 673 performance.

674 Mobile Data

675 This session consisted of four long and two
 676 short presentations. Powar *et al.* posed privacy-
 677 preserving data publishing as a risk management
 678 problem using the concept of linkability, which
 679 forms the basis of their novel threat modeling
 680 approach. He remarked that the dependence of
 681 their approach on the source of data has not
 682 been explored yet. Hasthanasombat *et al.* talked
 683 about how one can answer explanatory ques-
 684 tions from mobile data, e.g., how the existence
 685 of a venue would affect footfall or health out-
 686 come in this area. They employ causal inference
 687 methodology to deal with the mobile data since
 688 it is observational in nature rather than coming
 689 from a controlled environment. Varvello *et al.*
 690 talked about how energy measurements can be
 691 performed on mobile devices with high accuracy
 692 exclaiming that currently both hardware- and
 693 software-based solutions have limitations in
 694 terms of accuracy or are expensive. Singh *et al.*
 695 described how people’s mobile app usage habits
 696 are strongly correlated with the demography of
 697 the place. Their study found that urban areas
 698 are more dominated by apps like WhatsApp,
 699 Netflix, and blogging. By contrast, rural areas
 700 saw more traffic coming from background OS
 701 updates and streaming dominated by Windows
 702 phones. Participants enquired about their clus-
 703 tering approach and the use of mutual informa-
 704 tion metric.

705 Looking Forward

706 Next year’s event will again seek to attract
 707 faculty, researchers, innovators, and students
 708 from all stages of their careers. The event will be
 709 chaired by Prof. Mirco Musolesi and take place
 710 at University College London on the 6th and 7th
 711 of July 2020.

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