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BRINGING HOME BABY

Now that mobile phones are a ubiquitous computing medium, we are seeing a stream of connected (and sometimes intelligent) devices. It's interesting to consider whether these so-called "smart" devices can help new parents and caregivers of young children. In this article, some problem areas that might be quite simple are considered – except that the technology solution must be both childproof and accurate enough to entrust the health and safety of your precious cherub. AT CES 2017, a slew of products were introduced that attempted to do exactly that, to help reassure parents in some way.

REASSURING PROSPECTIVE PARENTS THROUGH THE PREGNANCY

Hearing the fetal heartbeat is a first major milestone in the pregnancy journey. This generally happens during an ultrasound, a sophisticated medical diagnostic tool that produces information used to date the pregnancy, rule out medical problems, etc. In addition to these medical benefits, it is undeniable that the procedure provides parents and caregivers with reassurance and a connection to the unborn child.

First up is the Kaishi [5], a fetal heart rate monitor for consumers that connects to a smartphone. Instead of using an active sensing technology (e.g., ultrasound or Doppler radar) that might adversely affect the health of the child when used by an untrained consumer, this device used microphones with software for filtering out unwanted sounds. As a maker, I thought this was a very clever use of an amplification circuit. The intended uses of the device are social in nature – it included a smartphone application that allowed the prospective parents to record the sound of their baby's heart, and share it with family and friends.

Another interesting device is the Bloomlife pregnancy wearable[6]. Also a smartphone-connected device, this wearable shows a real-time view of contractions. Typically, health care providers just need basic information about the frequency and duration of contractions. (My wife and I used a smartphone app when our baby was on the way but a clock would also probably suffice.) This was a clever use of unobtrusive technology (passive sensing) to make the process data driven and provide assurance to the prospective parents.

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TEMPERATURE TRACKING

A baby with a fever is a dreaded and inevitable event in the life of every caregiver. What makes things challenging is that untreated fever can lead to significant complications, for instance, febrile seizures. The tool used by parents for many years has been the dependable thermometer. Parents must struggle and fumble to take a temperature reading as babies aren't known for being the most cooperative patients. Alternatively, caregivers just use the in-ear, infrared-based forehead one, or even thermometers built into pacifiers [0], which simplify the task of taking a single measurement significantly. Leaving aside the perennial question of accuracy, the big challenge is how to monitor the baby through the night. Surely there is something better than sneaking up to the baby's cot in the middle of the night to take a temperature reading?

There are at quite a few attempts at solving this and other related problems. One of the most clever technology solutions for this problem is the TempTraq. This device is a single-use adhesive patch that can be stuck onto the baby. The patch continuously tracks the baby's temperature and transfers it to your smartphone. The patch is very impressive [1]. First off, it was designed to be single-use, with patches lasting for 24, 48 and 72 hours. It is amazing that computer hardware – microcontrollers, radio chips and temperature sensors – are so cheap now that it is not unreasonable to think of them as disposable. This is what ubiquitous computing was all about to some extent. Another interesting aspect of the patch was that it has be relatively comfortable – rigid components would make this quite difficult. The TempTraq solves this by using a thin film battery (made by the same company as the patch itself, Blue Spark Technologies). This technology is very exciting – the battery seems quite flexible although its form factor clearly affects other properties, such as energy density and ability to recharge. It turns out that the core technology is almost a decade old and there are several related offerings by different vendors. An independent market research firm estimates that the overall market for flexible batteries will grow to more than half a billion dollars by 2026 [2]. Another vendor of bendable batteries is Imprint

Energy, which got its start from research done at the University of California at Berkeley. Imprint Energy is aiming for their batteries to have a large number of recharge cycles as well as bending cycles – not something you find on the spec sheet of many batteries today.

In addition to flexible batteries, other technologies of interest to makers are flexible printed circuit boards (PCBs). PCBs mechanically support and electrically connect components and have traditionally been rigid. The explosive popularity of wearables and novel device form factors has led to the growth of flexible PCBs. Most flexible PCBs out there today do not seem to be intended for continuous cycles of bending. However, they do answer the call when a device, such as a watch or fitness tracker needs to be manufactured with curves. Building a high-quality flexible PCB requires careful thought on board layout and manufacturing concerns. An interesting idea used in some products is to have a series of small rigid boards connected by flexible PCBs [4].

To round out this discussion of flexible electronics, it's important to include flexible displays and digitizers. LG and Samsung have been showing prototype bendable display technology for several years. At CES 2017, a relatively new player called Royole (founded in 2013), showed off flexible digitizers and a concept curved phone called the Flexphone. Their booth had an interesting application of flexible display technology – to fit the contours of a car's dashboard. It will be very interesting to follow how this technology develops into commercial products in the years ahead.

PUMPING BREASTMILK

An innovative product announced at CES 2017 is the Willow breast pump [7]. What makes this a potentially game-changing device is how unobtrusive it is, compared to wearable breast pumps that are on the market currently. No dangling tubes to fuss with! As with many simple ideas, the genius lies in the execution. The breast pump fits inside a bra. For the milk-collection system, it uses a specially contoured plastic bag. It is bewildering to realize how effectively space had to be managed to create the Willow pump – the pumping mechanism, the milk collection bags, batteries for the pump and

all of the electronics! The overall industrial design also seems to be well thought-out. Finally, no connected device can be without a smartphone app these days. The Willow pump's app connects to the device and collects key metrics, such as time and duration of the pumping session, collected milk volume and allows the user to see past data and set reminders.

Of course, one size does not fit all. As a new parent, I was delighted to see this area getting interest from manufacturers. Some lactation consultants recommend using a hospital-grade breastmilk pump even at home. The Naya smart breast pump uses flowing water to help reduce noise [8]. Another pumping system, the Lansinoh [9], features a sophisticated smartphone application that helps track milk production, as well as information about the newborn (diaper condition, baby's growth, etc.).

SIMPLIFYING EVERYDAY LIFE THROUGH HOME AUTOMATION AND VOICE ASSISTANTS

I invested in an intelligent home assistant (the Amazon Alexa), as well as a home automation solution (Samsung Smart Things)[1] about the same time as our baby was born. The original application was home security and monitoring the temperature in the nursery. While the setup was useful for these needs, I was surprised at how useful a hands-free voice interface is when your hands are otherwise occupied: several fans, air purifiers, humidifiers and lights are plugged into smart outlets. The use of the voice-based interface is so predominant that one of our baby's first words was "Echo." Many people would argue that home IoT is yet to be firmly established. My experience is that home IoT is truly worthwhile for new parents.

Of course, there are problems that remain to be solved. Keeping a constant temperature and humidity level in the nursery proved to be a challenge. My apartment did not have independently controllable zones connected to an intelligent thermostat. Some of these issues are addressed by solutions such as Google's Nest smart thermostat. Using a portable humidifier like the one we

used is generally not a fully automated solution because the humidifier needs to be both filled with water and cleaned fairly regularly. On the other hand, many houses today have whole home humidifiers that simplify the process significantly.

Finally, I used a D-Link wireless camera mounted near the baby's crib. The camera was very useful when sleep-training the baby. This process involved letting the baby learn to go to sleep on her own, without parental involvement. Having a camera allowed me to make sure that the baby did not get into too much trouble. There are some technical aspects about the camera that were quite fascinating: it used local network discovery mechanisms (such as mDNS and SSDP) to quickly find and connect with the camera. This effectively addresses the sleep-training scenario, when my wife and I are at home but in a different room than the baby. The camera also supports useful features like connecting to the camera remotely (as a security-obsessed parent, I connected the camera to a physical power switch and only turn it on when putting the baby in her crib). In general, it seems like security is a somewhat neglected area in low-cost consumer electronic devices. Devices and solutions that address this aspect are bound to resonate with busy parents.

MONITORING BABY

In the last couple of years, several baby monitoring devices have come on the market. Examples include the Owlet sock [10] and the Mimo monitor [11]. The Owlet sock uses pulse oximetry to measure a baby's heart rate and oxygen levels while they sleep. The Mimo baby activity tracker essentially tracks a baby's movements when they sleep. Both devices connect to a user's smartphone and alerts the parents or caregivers when something amiss is detected.

When my wife and I had our baby recently, we investigated this space and did not find a solution, any product in particular, that met our personal needs. The problem we were worried about was SIDS (sudden infant death syndrome), a dread of many new parents, which is still not fully understood by the medical establishment. While monitoring systems out there currently attempt to help parents get a better sense of their baby's sleep, no solution claims to directly address SIDS.

In addition, we were worried about possible harmful effects of electromagnetic radiation so close to the baby's body. Finally, we read some reviews about parents woken up in the middle of the night by alarms that ended up being false. These factors made us think that we did not have a perfect solution to our baby-monitoring needs. I'm optimistic that as technology in this space develops, we will have an even more impressive slew of products that make meaningful improvements in the lives of parents, caregivers and, of course, baby. ∎

Disclaimer: *The views expressed in this article are the author's personal views and may not represent the views of his employer. While the article describes medical devices, no aspect may be taken as medical advice.*

Iqbal Mohomed earned his PhD from the University of Toronto in 2008 and, after doing post-doctoral research at Microsoft Research Silicon Valley, he joined IBM Research. Presently he is a senior staff researcher at Samsung Research America. His research interests are in sensors, distributed systems, cloud and mobile computing.

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[1] In the interest of full-disclosure, the author of the column is currently employed by Samsung.