KidCam: Toward an Effective Technology for the Capture of Children's Moments of Interest

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Abstract. Mobile applications of automated capture present many interesting design challenges, balancing the desire for rich media against ease of use and availability. In particular, capturing rich media of young children has many potential benefits, but remains a difficult challenge due to the many unique constraints of recording children. Motivated by the aim of supporting a parent's need to record the life events of a young child, we have designed KidCam, a prototype rich media capture device. This paper presents the design, implementation, and evaluation of KidCam and its goal of addressing some of the challenges of recording young children. Results from a three-month study with four families show that KidCam addresses some of the challenges of recording rich media of children, but there are still remaining hurdles. We discuss these remaining challenges, potential ideas for how they could be addressed, and emergent uses for KidCam beyond the initial domain for the creation of family memories.

1 Introduction

The capture and access of rich media, such as audio and video, has many potential applications [4,8,9,22] and is one of the three central application themes of pervasive and ubiquitous computing [1]. Our particular interest in this paper is the use of these recordings to support the collection and reflection of children's moments of interest by parents and families. Past capture solutions usually assume a static capture infrastructure, limiting their coverage across spaces, such as all rooms in a large home. Although mobile capture and access applications have been implemented to monitor activities of daily living [20], generate field reports for soldiers on patrol [21], and provide tourist services [6], they typically involve wearable computers, on-body sensing, or both. Despite the potential benefits of these applications, there are many issues associated with these wearable systems, such as weight, fragility, and heat dissipation, which may make them unsuitable for a general population, especially children and

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individuals with special needs [16]. In this paper, we explore how mobile technologies can be designed and developed to aid in capturing rich media experiences in the lives of young children.

The inspiration for a non-wearable, mobile capture and access device came from a need to support parents of young children in documenting important moments of their child's development [17]. For example, many families with children purchase a digital camera, a camcorder, or both for the purposes of recording their child's special moments and development. Parents share these recordings with others, such as grandparents, and archive them for sentimental reflection when the child is older. In addition to collecting keepsakes, many parents may wish to remotely monitor their child while they are asleep or otherwise away from them, and thus often purchase audio or video baby monitors. Parents with questions about their child's development and may wish to record information to share with a pediatrician or a specialist. In addition, there has been increased use of home movies of children to assess how childhood disorders look at young ages [4].

The prevalence of these digital recording devices has grown dramatically over the past decade. Many people own multiple recording devices, including digital cameras, video camcorders, camera phones, web cams, security cameras, and more. However, the presence of these devices does not ensure the capture of important events nor the ability to find and retrieve the relevant media. One of the problems that can arise from owning so many devices is the variety of media types that can be recorded, which can cause people to become overwhelmed with the choice of recording device and storage media. This can prevent both capturing the event and later viewing or sharing the event with others. A further complication is that many traditional capture devices have limited storage and thus do not support continuous recording, which allows people to capture unplanned events.

A potential solution to these issues may be to combine many recording features into one single, semi-mobile, and semi-continuous recording device – a design space that has yet to be explored for this domain. However, how do we design such a device so that it incorporates many of the desired recording features without overwhelming the user? How do we determine if mobile recording is appropriate for this particular domain? To answer these types of questions, we explored the problem by designing such a device with this context of use in mind. The device we designed, called KidCam, was based on our previous research in mobile and continuous capture and design requirements for technology for supporting families [17]. KidCam has the goal of enabling families to record their children's moments of interest through the continuous collection of video using a buffering technique that allows the manual recording of spontaneous segments of videos and remote monitoring and capturing. To determine whether this new design space is appropriate for families in realistic settings, we evaluated the effectiveness of this device through a three-month, long-term deployment with four different families with young children. We found that although we designed KidCam for and with families, there are still some remaining challenges in capture for this domain.

In this paper, we begin with a discussion of related work in mobile capture and access and record-keeping for young children. We then discuss a classification of recording approaches and how KidCam addresses a gap in existing recording technologies. Next, we discuss the design requirements we used for building a capture device for recording children and provide an overview of the prototype application. We then continue with a description and results of the three-month evaluation of KidCam by four families. Finally, we discuss the implications for the results of our study and how the field of research in mobile capture and access can be moved toward more effective technologies for recording children's moments of interest.

2 Related Work

In this section, we discuss how our work relates to and expands upon previous work in relevant areas. This work includes projects related to mobile capture and access applications along with their associated techniques supporting record-keeping for young children. We also provide a discussion of a classification for existing recording technologies and how KidCam fills a particular gap.

2.1 Existing Capture Technologies

In recent literature, there has been a large amount of work in understanding and providing for the mobile capture of rich media such as audio, video, and photographs. Several studies have looked at how people use camera phones [18,19] and digital cameras [7] to capture pictures and video segments for personal and social purposes. These studies aim to understand current practices for how people use the devices they already own, rather than explore the design of new devices. Other researchers have designed and built devices that provide automated capture, including one that automatically takes photographs based on scene changes [14] and a proposed system for automating experience capture for tourists [3]. Although these systems are similar to what we have built in terms of automating the capture process, they differ in features and purpose. KidCam supports a variety of capture types, including both still images and video, and combines everything into one stand-alone apparatus suitable for both stationary and mobile use.

Other mobile systems have supported more traditional capture and access in that they support a specific domain. The Personal Audio Loop [10] is an audio-based wearable system that is used to support near-term memory recall, but does not allow users to save events for future use. The Soldier Assist System [21] is wearable and supports the collection of still images, video footage, environmental audio, spoken audio, and motion information along with automatic indexing into this data for the purposes of supporting post-patrol debriefings. However, this system is very cumbersome to use, requiring the soldier to wear multiple pieces of hardware that would be very awkward in civilian settings.

We provide means for recording spontaneous and unplanned events by allowing for a buffering of video data. Others have explored the use of this type of technique to help classroom teachers identify the causes of children's behaviors [10] and record information in informal meeting spaces [12]. Other systems provide automatic triggering using sensors, such as the SenseCam platform [14], which takes still pictures based on sensor data built into the device (*e.g.,* light sensors, GPS data). StartleCam [13] is a wearable camera that circularly buffers data and automatically archives pictures when the user experiences a startle, which is measured by a significant change in their skin conductivity. The HP Casual Photography project describes another wearable system which constantly record videos and pictures for later viewing [23]. KidCam differs from these by recording not just still pictures, but rich video and audio as well. In addition, all four of these projects require playback or viewing of pictures on a separate device, whereas our system supports the reviewing of videos and pictures on the same device.

In the specific domain of recording young children, the Human Speechome Project [24] uses an extensive recording infrastructure throughout a house to gather linguistic data to help researchers ascertain how children acquire language. While our system could make use of an extensive video recording infrastructure, we aimed to build a device that could be moved from room to room and to places outside the primary home of the child. Though we may sacrifice the amount of footage our system will collect, we believe our system enables capture in more places and will enable parents to collect only the videos they want without as much invasiveness.

2.2 Classification of Existing Capture Technologies for Children

One useful way of classifying existing recording technologies is through two separate dimensions. These dimensions are whether the recording happens continually or whether it is on-demand and whether the devices cover a single, fixed space or are highly mobile. A review of the existing strategies for capturing rich media of children's moments of interest revealed a particular gap in the needs. In particular, existing recording technologies tend to be on the extremes of these two dimensions. While there are benefits at the extremes of each of these dimensions, there are also disadvantages that prevent a desirable and easy-to-use recording system that can capture unplanned moments throughout all the locations a child may need to be. Figure 1 shows a diagram of the capture dimensions and how KidCam fills that gap.

Along the dimension of continuousness is a spectrum of devices that continuously record information without any intervention (*e.g.*, security cameras) at one end and those that only record when explicit user action is taken (*e.g.*, a digital camera) at the other end. The advantage to the continuous recording at the extreme end of the spectrum is that every event is recorded and likely nothing would be missed. The disadvantage to this end of the spectrum is that there are social concerns over privacy and technical problems of storage and searching through many hours of footage to find the appropriate moment of interest. In addition, the quality of this type of recording may be compromised for the sake of storage space or privacy. At the opposite end of the spectrum is the notion of on-demand capture. This has the advantage of being precisely what the user intends to capture and is often of higher quality in terms of captured content. However, the disadvantage to this end of the spectrum is that it is often difficult to capture unplanned moments. The center of this axis is a middle ground where data is constantly recorded but only saved when the user explicitly takes an action. The selective archiving approach described by Hayes *et al.* [10] meets this middle ground.

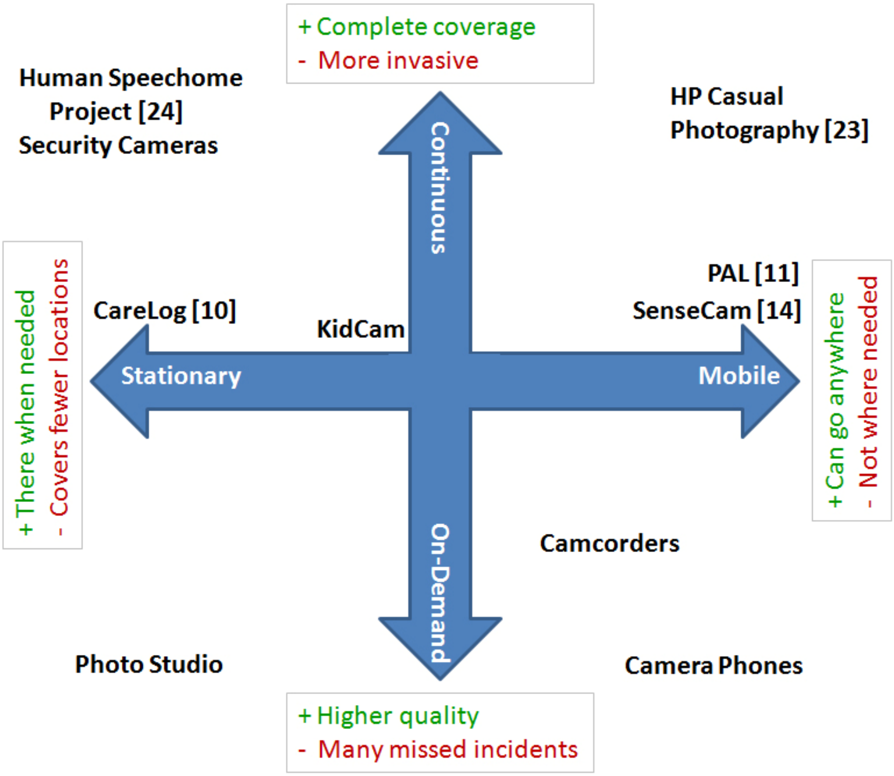

Fig. 1. Classification of existing capture technologies along the dimensions of continuousness and mobility

The second dimension of capture in relation to children's moments of interest is along the axis of mobility, which ranges from stationary (*e.g.*, cameras permanently affixed to a wall) to completely mobile or wearable capture devices (*e.g.*, camera phones). At the stationary end of the spectrum, the advantage is that the capture device is always in a particular space and that space is always covered if something happens. The disadvantage to this is that the device only covers this space, and if events of interest occur outside of the covered location, the event will be missed. Because children are often mobile and have many different areas where events occur, it would be difficult to provide coverage for all potential areas of interest. At the other end of the spectrum would be a completely mobile system that could be anywhere the child may be, such as a wearable device. The advantage to this is that the device can capture events anywhere. The primary disadvantage to the mobile approach is that it is possible the device would not be in the correct location or orientation when the moment of interest occurs. In addition, mobile capture devices tend to be fairly low quality due to their need for compactness and have limited storage capabilities. At the center of this spectrum is a device that is portable enough to be taken anywhere, but can still be placed in a fixed location while in a room.

Because of the disadvantages of each of the far ends of the two dimensions, we designed KidCam to meet at the halfway point of each. KidCam uses a selective archiving technique that constantly buffers when running, and parents can choose to save videos from a 20 minute buffer stream of past recorded events. For mobility, the device is lightweight enough to be easily moved from location to location, but comes with a built-in stand that can be set in a fixed location, thus is considered semi-mobile. One interesting note is that there is a second gap in the classification, which is in the area of semi-mobile but fully continuous. This could describe a technology that is constantly recording, but can be easily moved from one location to the other.

3 KidCam: Design Requirements and Implementation

In this section, we describe the specific design requirements we used based on our analysis of the design space for capture technologies and a formative study on technologies to support recording data on young children. We also provide an overview of how these results influenced the KidCam prototype implementation.

3.1 Design Requirements

The requirements for KidCam came through an in-depth formative study we conducted on how new parents might wish to record their children's developmental progress [17]. In this study, we interviewed new parents, experienced parents, secondary caregivers, and medical professionals on the design requirements for how designers might develop technology to support record-keeping for young children. From this work, we determined several important considerations and challenges for recording technologies for children.

- Families enjoy taking digital pictures and videos of their children to preserve sentimental memories and share with family and friends. Digital photos allow them to take multiple pictures to try to get the "best shot." Videos allow them to record their child's voice and actions and are often used during special occasions, like birthday parties and holidays.
- Parents do not need or want to continuously record every move. Rather, they care most about recording interesting moments, such as accomplishing a significant milestone, such as saying their first words, or a sentimental purpose, such as reading a bedtime story together. Very young children also sleep for a significant amount of the day, so continuous recording may not be necessary. Thus, shorter, filtered video segments are optimal.
- Children are in several locations throughout the day. Although they may have bedrooms with cribs, they are often in the living room, the kitchen, a playroom, or parents' bedrooms. They may also visit daycare centers or the homes of childcare providers where they also spend a significant amount of time. Thus, capture systems should be mobile enough to work in many places.
- It is difficult to predict when moments of interest may happen. A parent may prompt a child to do various activities, but many times a child will spontaneously act when a parent does not expect it. Any recording technologies should be able to capture these unplanned moments.
- Continuous, always-on video recording may be more invasive than a mobile device where parents control the recording. In addition, a mobile solution

would alleviate having to instrument an entire house with cameras, which can be impractical for everyday use and violate home aesthetics.

In designing KidCam, we aimed to build a technology that would meet each of these considerations and enable parents and caregivers to record throughout the home and other places where the child may go, such as daycare or the home of another caregiver. We followed an iterative design process to ensure that KidCam was meeting the needs of the users for which we were designing, including some low-fidelity prototyping and short-term evaluations on the interface design.

3.2 Overview of Prototype Implementation

The final design of KidCam uses the Sony VAIO™ UX running Windows XP, an ultra-mobile PC (see Figure 2), though any model of ultra-mobile PC would work. The VAIO has two built-in cameras (one on the front and one on the back), a microphone, a touch screen interface, a mini-qwerty keyboard, Bluetooth and 802.11 wireless communications, and 30 GB of storage space. We then wrote a software application using C# that provides a user interface and supports all of the capturing and reviewing of the audio-visual data.

The user interface is themed as a child monitor and recording device, which child-friendly graphics and colors and large widgets for touch-screen interaction. The basic functionality enables the recording of video, audio, and still pictures using either the front or the back camera, as well as reviewing multimedia data based on different annotations that are provided either during or after capture. A commercially available mobile RAM® mount stand was added to the system to allow people to situate the device and camera to whichever angle they need in a variety of environments. When attached to the mount the entire unit stands about 9 inches (23 cm) high. The device can be easily removed from the stand for hand-held recording and viewing. The battery life of the device enables it to run for approximately 1.5 to 2 hours while unplugged. We recommended that parents leave the device plugged in while it is situated in the stand. Overall, the device is completely mobile when detached from the base, and measures approximately 6 inches (15 cm) wide, 4 inches (10 cm) high, and 1.5 inches (4 cm) thick, and weighs 1.1 pounds (0.5 kg). When attached to the base, it is slightly less mobile weighing approximately 3.75 pounds (1.7 kg).

Fig. 2. View of KidCam prototype on a Sony VAIO (left) and a screen shot showing the main menu of KidCam's interface (right)

3.3 Continuous Video Buffering for Saving the Past and Future Events

To archive videos, we wanted to allow for continuous recording during an event and have users specifically choose to save videos either during, before, or after an event occurs. To accomplish recording prior to an event, users can set the recorder to save video for a specified number of minutes in the future. For example, parents may witness their children spontaneously take their first steps and wish to go back and record those moments, or at the child's first birthday party, the parent may set KidCam to record from the beginning of opening presents until they are finished. Thus, we implemented a video buffering system similar to that which a digital video recorder uses. The concept of our design was similar to that of the notion of selective archiving [10], which allows for saving only the past events of interest. When the user chooses to save a video file (see Figure 3), she specifies how far in the past and how far into the future to save the video using a range slider widget. The device then copies a segment from the buffer to a video file that corresponds to the beginning and ending of the desired video segment. While the device is buffering multimedia data, the interface shows a live preview of the video so it can be easily positioned to the desired angle while in the stand or used like a handheld video camcorder.

Fig. 3. Interfaces for previewing current capture of KidCam (top) and saving videos using sliders to indicate the start and stop points to archive (bottom)

3.4 Remote Monitoring and Remote Capture

Parents may want to capture video or photographs where they cannot be present or it would be inconvenient to be present. For example, if a child is napping in her crib, the parent may wish to monitor from the kitchen while he is making dinner. Alternatively, a parent may wish to monitor his child at daycare from his desk at work. Because parents may already be using a baby monitor to monitor their child while sleeping, this may also encourage them to have the device near their child more often, which may in turn increase the opportunities to capture spontaneous events. Thus, we wanted to develop a way of remotely viewing and triggering the KidCam. For our implementation, we used the Nokia n800 Internet Tablet™ to create a remote connection over an ad-hoc wireless network between itself and the KidCam (see Figure 4). The remote connection copies the screen of the KidCam to the Nokia and provides for remote interaction through the touch screen of the Nokia Internet Tablet. The live audio-visual feed from the KidCam can be remotely accessed on the internet tablet, though at a reduced video frame rate.

Fig. 4. KidCam's interface can be remotely viewed and controlled via another device (*i.e.*, a Nokia Internet Tablet) that can replicate its screen and audio

3.5 Media Reviewing Interface

Users of KidCam may also need to review videos in a variety of locations. For example, if parents have recorded videos of their child playing with toys a relative has given her, they may want to show it to that relative while at their house for a visit. Thus, we have implemented a file viewing interface for the device that enables quick reviewing of videos and pictures (see Figure 5). The media file reviewing interface is divided into a screen for reviewing videos and a screen for reviewing still pictures. The video review screen allows the user to sort the files by date and time, length of video, or name. In the list, when the user clicks on the video file, it will play the video. The still picture review screen is similar to the video review screen, but shows thumbnails instead of text labels for easy viewing. For both the video and the picture reviewing interfaces, the user can choose to delete videos and pictures they no longer want to keep. They may also choose to "export" videos, which will copy them to an export directory for later synchronization with a home computer.

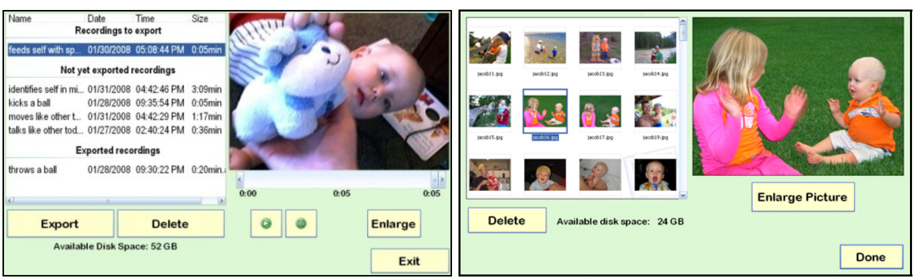

Fig. 5. KidCam interfaces for reviewing videos (left) and still pictures of their child (right). The video and the pictures can both be enlarged to take up the full screen.

4 Evaluation Study of KidCam

In this section, we describe the design of and results from the KidCam study, in which we provided the device to four families to use over a three-month period to capture their children's experiences.

4.1 Study Design and Participants

The iterative design process showed that KidCam was functional and could successfully capture data. However, we wanted to evaluate the effectiveness of KidCam in a manner that was ecologically valid and to determine if it was actually useful to families. Thus, we deployed the device with four families for approximately 3 months. The goal of the study was to evaluate the use of KidCam in realistic settings with real families and determine how often parents would run the device and how many photos and videos they would capture and review using the device. We also wanted to expose any problems with the design and refine our design requirements to develop future versions of the KidCam system.

Families in this study were recruited as part of a larger study investigating technology solutions to support record-keeping of young children [15] and were given KidCam in addition to a software application for tracking their children's progress. We recruited 4 families who were all clients of a single pediatrician's office in a suburb of Atlanta, Georgia. All families were of similar demographics and socio-economic statuses, which was college-educated, middle class, married, and with two parents in their early to mid 30s. Three of the families were American-born, and one of the families (Family 2) had a father who was born in South America. All families were computer literate and were familiar with digital photos and digital cameras. The number of children in each family was either 1 or 2, and all children in the study were aged 5 and under. Table 1 shows the composition of each of the four families we recruited for our study. The families in the study were compensated monetarily for their participation in the study as a means of recruitment and retention over the 3-month period, but it was not in any way contingent on using the system.

For the study, each family was given a KidCam recording device and a remote viewing device (*i.e.,* a Nokia internet tablet). They were instructed on how to use the system, but were told to use it however they wanted and were not given any specific instructions. They also had a developmental milestone tracking technology installed on their home computers, which they could use to synchronize the videos and pictures

Table 1. Overview of families recruited to evaluate the KidCam system

Family ID	Number of Children	Children's Ages	Children's Genders	Both Parents Working?
1	2	12 months, 4 years	M, M	No
2	1	9 months	M	Yes
3	2	9 months, 3 years	M, F	No
4	2	15 months, 5 years	M, F	Yes

taken with KidCam to their home computers. Synchronizing KidCam with the home computer also updated a list of three upcoming milestones for which parents should be watching. We logged all interactions with the KidCam device to its local hard drive, as well as all photos and videos recorded (unless the parents explicitly deleted them). Prior to being given the device, we interviewed parents about their current techniques for capturing and reviewing their children's moments of interest. We also met with them once halfway through the three month time period to download the logs, photos, and videos and conduct a mid-study interview on their use of the device and suggestions for improvement. We conducted a similar meeting at the end of the three-month period, where we also collected the device and conducted a final interview, which probed on their use of KidCam, suggestions for improvement, and a description of their ideal recording device. Following the study, each interview was transcribed for further analysis.

4.2 Study Results

In this section, we provide data on the general usage of KidCam by each of the families as determined by the logs. We then present the general perceptions of KidCam from the families as reported during the mid-study and final interviews.

4.2.1 Overall Use

The videos that parents recorded were appropriate for what might be needed for preserving child memories or aiding a pediatrician in analyzing whether a child has achieved a developmental milestone. They tended to be shorter segments of the child's development or fun experiences they wanted to save for later, with the average length per video being 3 minutes, 43 seconds. Family 2 recorded longer videos in general, because they used the device to record the child's family events, such as the dinner for his first birthday party. For photos taken with the device, the quality was not as high as what parents were used to with digital cameras, which is why parents reported that they did not use that feature often.

Overall, use of KidCam was lower than we expected. Parents reported in their interviews that they did not have a practice for setting up KidCam regularly and thus did not have it running unless they explicitly remembered to get it out and set it up, which is not often in busy families with small children. In total, KidCam was only running an average of 12 hours and 27 minutes across 16.5 days during the entire

Table 2. General usage of KidCam for each of the 4 families in the study

Family ID	# of videos	Average video length	# of pictures	Total running hours	Number of Days of Use
1	10	0 min., 54 sec.	1	8 hrs, 10 min	11
2	16	7 min., 13 sec.	10	3 hrs, 16 min	20
3	3	5 min., 19 sec.	3	15 hrs, 25 min	15
4	9	1 min., 28 sec.	2	22 hrs, 58 min	20
Average	9.5	3 min., 43 sec.	4	12 hrs, 27 min	16.5

three-month period. In addition, families averaged 9.5 videos and 4 photos per family at the end of the study. This does not include videos and photos that were recorded but deleted, which for some families, was fairly often due to their varying uses of the device explained below. Table 2 shows the individual usage for each of the families. Despite the lower than expected use, when parents did use the device, they liked the buffering capabilities and the ability to record unplanned events. We discuss more about how we can improve frequency and utility in Section 5.

4.2.2 User Perceptions

In general, the families in our study liked the concept of KidCam, despite their low use of it. They appreciated the functionality and ability to capture unplanned moments while KidCam was in the room and turned on. The size of the device was appropriate, and the stand made it easy to situation to view the room. Most parents reported said they just forgot to turn on the device when they were playing with the child or forgot to move the camera when the child moved to a different space. Parents reported that they rarely used the baby monitor function because it did not provide much functionality beyond their already existing baby monitors. Many described it as being more complicated to use than their existing monitors. In addition, parents typically only used their baby monitors while the child was sleeping and did not think their child would do anything interesting while they were sleeping.

> **Mother, Family 3:** *"[A baby monitor] is only for when he's sleeping and he does nothing we want to record when he's sleeping… the reason why it was nice to have KidCam is because it would capture things awake. But like I was saying, nine times out of ten he was over here and it's so far away that it doesn't get him…"*

Parents became discouraged when they did remember to start KidCam and try to play with their child to get them to do interesting actions, but the child was not in the mood to perform. They also commented that KidCam itself became an attractive toy, and when they would interact with it, the child became interested in the device itself and want to play with it or watch themselves on the camera's playback screen.

> **Father, Family 4:** *"He'll do something and it will be so fascinating, and then when you try to get the video to record it, the process of going to get it, or whatever, set it up. Then he'll be distracted by it, and it's like, "Oh, let me look at the toy." Rather than do the trick."*

Family 1 used KidCam as a way to record and analyze their child's activities. The mother reported wanting to record and save her child's progress, but only if she was unsure about whether the child was able to do something. That way, she could go back and play what he had just done to see if he had actually performed the skill correctly. She mentioned that if she knew her child could do something, she did not feel the need to record it.

> **Mother, Family 1:** *"If I knew it, then I wasn't going to record it. But if I wasn't sure, then I got the video thing out and I went through the list of what I wasn't sure of. Like I really wasn't sure about, for example, that throwing the ball. And even when I got it on video I replayed it a couple of times to make sure…"*

Besides just recording videos for review later, Family 2 used KidCam as a way to immediately play back what had happened when they were not in the room. However, the mother said she did not feel the need to save these videos because they were only for entertainment as opposed to trying to capture a specific moment for later.

Mother, Family 2: *"And the video is always more fun because I can just turn it on. And what was nice with the video, I think I did last week, is I had to come downstairs and make his breakfast, so I put the little KidCam in there while he was playing in his crib. And it was kind of neat to go back and see what he does when I'm not around."*

For the families with older children, several parents mentioned that the children liked to perform for the camera and watch themselves on the playback screen. The mother of Family 2 reported that this generated a significant number of videos that they did not necessarily want to keep, so they deleted them after the child was finished.

The pictures that families took tended to be of their child doing cute things or making silly faces they wanted to save and maybe share with family later. Videos were taken of a specific special event, such as Family 2 and their child's first birthday party, parents playing with their child trying to get them to do specific actions, or children doing silly things such as singing a song, dancing, or making a mess with cake. Video and picture content seemed to depend on the family, as Family 1, which had a history of developmental delay, took more videos of developmental activities such as stacking rings and jumping, while Families 2, 3, and 4 focused more on sentimental activities like playing and family time. Figure 6 shows an example of a video and a picture taken by Family 1 and Family 2 respectively.

Finally, despite being satisfactory in initial usability studies, the prototype KidCam device was a bit cumbersome for everyday use. Because the UMPC was a Windows XP machine, parents had to wait for it to boot before beginning to use the device and then wait for the application to load and the video to begin buffering, which could take several minutes. This often happened when parents forgot to plug in the device and charge the battery. In addition, touch screens are not necessarily optimal for quickly taking pictures. The baby monitor required starting up a second device and

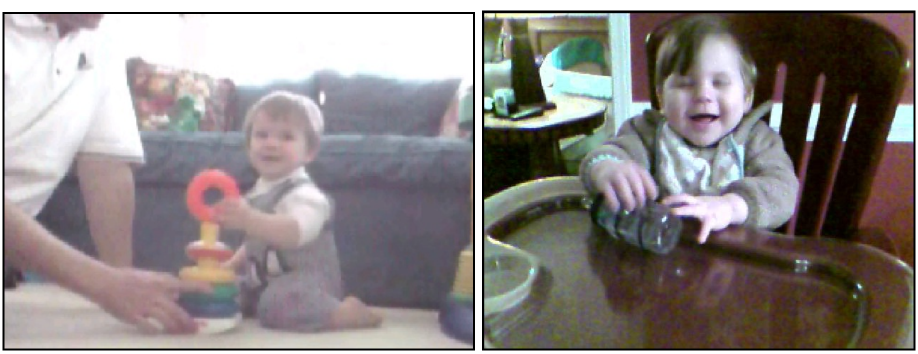

Fig. 6. Still from video taken by Family 1 of their child stacking rings (left) and photo taken by Family 2 of their child having breakfast (right)

application and took even longer to get started, which is the main reason cited for not using that feature. As a side note, these results highlight the usefulness of real-world deployments, as they did not surface until parents tried to use the device in real situations.

5 Discussion, Implications, and Future Improvements

Through the implementation and evaluation of a prototype that attempts to balance two dimensions of recording, continuousness and mobility, we have uncovered additional challenges and potential solutions for the difficult problem of recording children's moments of interest. In this section, we discuss the implications for this design space and how future improvements to KidCam can address these problems.

Quality of recorded media. There were many considerations and tradeoffs we needed to make in designing and implementing this device for recording young children. The requirement of semi-mobility meant that we had to sacrifice some features that would be needed for various aspects of child recording. For example, the requirement to capture video using a single, self-contained mobile device meant we had to sacrifice high-resolution video and recording from multiple angles simultaneously. This lower quality, single view video and low resolution photographs may affect what the media can be used for in the future. For example, parents desire higher quality photographs for printing or keeping in scrapbooks and the videos are not high enough quality for any sort of automated analysis or tagging using computer vision techniques. The quality on smaller off-the-shelf devices may improve with time, and could be improved now by making a custom hardware device.

Need for semi-automated continuous capture. The second dimension of the design was to provide for semi-continuous recording through the use of buffering and selective archiving. While many parents appreciated this approach to recording, the device was not quite continuous enough. There was a separate step in turning on the recording device to begin buffering, which we contribute to be the biggest hurdle to high frequency of use. Redesigning the device to run continuously without the extra step of booting it and turning it on could significantly increase the frequency at which the video buffer is available for recording. Thus, in the classification described in Section 2.2, we believe that KidCam should be moved toward the continuous end of the continuous *vs.* on-demand dimension.

Need for quick interactions. While parents liked the idea of being able to go back and choose the time and precise times for the archived video, in practice it just took too long to find the specific start and end points for a particular video, when parents were already likely busy and wanting to interact with their child rather than review portions of the video to decide what to save. The small screen size and touch screen interface of the ultra-mobile PC were also not ideal for quick interactions. Thus, we suggest keeping this feature for those who want it, but also providing the ability to do a "quick save" by just tapping a button which will save a small video clip with a preset start and end point around the point of capture. We could accomplish this by using a physical button on the device, a remote control (similar to how the CareLog system [10] initiated the recording of videos), or through voice commands.

Semi-automated trigger of media archival. The use of KidCam required parents to manually trigger when events of interest occurred that they would like to save for later. In practice, this was somewhat problematic, as a parent interacting with a child may not have the time to go to the device to manually trigger the recording. We suggest that future technology might employ the use of wearable or environmental sensors or computer vision to detect the presence of individuals in the scene to occasionally archive pictures and videos while moments of interest are occurring. This could be through communication with accelerometers embedded in different child's toys or special markers stitched onto children's clothing. This adds an additional task for parents to decide on rules for when automated capture should occur. These rules can be designed to occur by default, or could be programmed by parents using an end-user programming environment such as CAMP [25].

Better integration into existing lifestyles. We intended for KidCam to be used as a baby monitor to encourage more frequent use. However, the device was not as easy to set up as commercial baby monitors. Furthermore, parents did not typically associate baby monitors as something they used while the child was awake. Thus, we believe that KidCam needs to rely less on parental interaction and designers should find additional ways to build recording into the family's life. For example, the camera might be integrated into a favorite stuffed animal of the child or capture from existing video baby monitors that the family already owns. In addition, parents reported just forgetting to turn on the device when they were playing with their child. Recording technologies could be tied to an explicit activity that parents do anyway, such as initiating video buffering when the light switch in the child's bedroom is turned on. In addition, video buffering could be automatically activated during times of day when the children are most active. Finally, the device could be made more child-friendly so that older children can also participate in the recording process.

Physical design of the capture device. In addition to the need for physical buttons for triggering the capture of the media, we learned several other valuable lessons about the physical design of the device. The size and weight of the current device were about right for a semi-mobile device. However, one aspect to consider may be durability and cost. Parents thought KidCam was fairly expensive and fragile and thus wanted to keep it out of reach of their children. However, the device had a nice screen and was colorful, so naturally attracted children to want to play with it. Thus, KidCam should be redesigned to be durable enough to withstand a child playing with it, similar to commercially available digital cameras built specifically for children. In addition, steps that can be taken to reduce the cost of the device may lead parents to take more risks with the device. It can also increase the range of families that can have access to the recording device, as the technology used for the prototype was fairly expensive and may be beyond many families' budgets for technology purchases.

Issues of privacy. We expected there would be concerns over privacy from the semi-continuously recording capability provided by KidCam. Because the device is portable, parents can take it to a variety of places with other people present who may not consent or be comfortable with to continuous recording, even if the buffer deletes video that is older than 20 minutes. For example, a parent may take their child to play group at another person's house and want to record her interactions with the other children. However, in our study, we found that parents only used KidCam at home and did not take it to other places. In addition, because they were in complete control of the position of the device and what was in the field of view and could see what was being recorded, they did not feel a sense of invasion. This also suggests that the ideal placement of KidCam on the continuousness dimension could be more toward the fully continuous end of the spectrum and more automated recording techniques may be appropriate for this domain. In addition, it indicates that a child-specific recording device can be thought of as an appliance for the home, rather than a truly mobile or wearable device.

Uses of a semi-mobile, semi-continuous capture device in other domains. Though we designed KidCam to be used by families of young children, there are aspects that will be useful for a variety of applications. Through interviews with families and further analysis of applications, we uncovered several emergent uses of KidCam that are quite different from our original design requirements. For example, people may want to record family or friends in a variety of places, such as at holiday dinners or parties. Teachers may want to record different activities throughout a school for training newer teachers on how to improve their teaching skills [2]. Other uses might be to support recording for traditional capture and access in more than one location. The traditional capture and access model in ubiquitous computing was to instrument a space, such as a classroom, meeting room, or operating room. This mobile architecture allows the model to stay with a single person, such as a teacher, a meeting manager, or a physician. However, changes in the context of use will require the design to adapt certain capture behaviors, such as to record longer videos in meetings or classroom lectures.

6 Conclusion

The capture of rich media for young children remains a difficult but interesting challenge. In this paper, we explored the design and use of a mobile capture device, called KidCam, which allows families to capture video and photographs of children for generating sentimental keepsakes and monitoring activities. KidCam was designed to fill a void in capture technologies along the combined dimensions of mobility and continuous recording. However, a three-month deployment study with four families showed there were still problems. Despite the lower than expected usage of the device, parents identified interesting uses of KidCam and helped reveal additional design guidelines for the space of mobile capture and access. The study also underscores the importance of conducting real-world deployments when evaluating pervasive computing applications, as data from our formative evaluations did not predict some of the problems uncovered by parents.

The main contribution of this work was to explore the design space of mobile capture and access for a specific domain beyond existing work. A classification scheme of existing devices along two dimensions – continuousness and mobility – showed that KidCam addressed a gap by being semi-mobile and semi-continuous. We identified that this technology still suffered from some of the same disadvantages as other existing technologies within this classification, such as the camera not being turned on at the appropriate times and manual capturing interfering with family activities. We suggest that further design exploration is needed to make KidCam more continuous, rather than semi-continuous, through the use of automated recording techniques and semi-automatic capture through the use of sensors or through more pervasive actions of parents. The study of KidCam showed that this space, although full of challenges, remains a high-need domain for technology researchers to explore.

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