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MEBOOK: A Novel Device Using Video Self-Modeling to Enhance Literacy Among Children with ASD

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Title: MEBOOK: a novel device using video self-modeling to enhance literacy among children with ASD

Background:

Reading books with children improves their literary skills. Children with ASD often cannot fully engage in the story due to off-task behavior and short attention span. Better self-regulation has been reported with interactive digital books or ebooks (Pykhtina et al., 2012). Ebooks also open doors to the use of new sensors. This work focuses on an innovate use of a color-depth (RGB-D) camera to incorporate video self-modeling (VSM) into ebook reading.

VSM uses specially-prepared video of the child to model a target behavior (Dowrick, 1983). It is an evidence-based intervention shown to be effective for various learning tasks (Buggey, 2009). To combine VSM with ebook, we propose to portray the reader as the protagonist of the story in a video shown next to the ebook. We hypothesize that the visual immersion of self into the story can better hold the attention and promote self-regulatory activities.

Objective:

The aim is to build a video application, MEBOOK, to overlay features of the protagonist on the face of the reader and replace the scene background with animated video pertinent to the story.

Method:

MEBOOK runs on a computer equipped with a RGB-D camera. The depth data allows us to separate the reader from the background and to track a 3D model of the face in real-time. We use the 3D model to insert synthetic objects that are geometrically aligned with the face independent of pose and motion. For example, the trunk and the ears of Dumbo can be visually attached to the reader's face. Also, the 3D model allows us to adjust the viewpoint so as to create the illusion that the reader is looking directly at him or herself. The separation of foreground from the background is akin to the "green"-screen technology used in newscasts to substitute in a more suitable background, such as a real jungle video, while leaving the foreground objects intact. The user interface of MEBOOK has the rendered video next to the story text. Highlighted keywords allow the reader to change characters and background video.

Results:

This study is to demonstrate the feasibility of MEBOOK, an application that utilizes a RGB-D camera to capture a 3D model of a child which is used to render self-video depicting the reader as part of a digital story. Using an appropriately chosen story, we will demonstrate the real-time response of the system, the overall quality and robustness of the rendering as well as the intuitive and engaging user interface of the overall application.

Conclusion:

We have designed a software application, MEBOOK, to enhance digital story books with interactive visualization tools, making them suitable for children with ASD. The novelty is the use of the child's face as a character in the story, a form of self-modeling, to engage the child in the story. A subsequent study to measure the effectiveness of MEBOOK in enhancing comprehension and self-regulation in reading among 5-7 years old children with ASD is underway.

Olga Pykhtina, Madeline Balaam, Sue Pattison, Gavin Wood, and Patrick Olivier. 2012. Magic land: play therapy on interactive tabletops. In Proceedings of the 2012 ACM annual conference extended abstracts on Human Factors in Computing Systems Extended Abstracts (CHI EA '12). ACM, New York, NY, USA, 2429-2434.

P. W. Dowrick. Self-modeling. In Using Video: Psychological and Social Applications. New York: Wiley, 1983.

T. Buggey. Seeing Is Believing: Video Self Modeling for people with Autism and other developmental disabilities. Wodbine House, 2009.

MEBOOK: A NOVEL DEVICE USING VIDEO SELF-MODELING TO ENHANCE LITERACY AMONG CHILDREN WITH ASD

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INTRODUCTION

Reading books with children improves their literary skills. Children with ASD often cannot fully engage in the story due to off-task behavior and short attention span.

Better self-regulation has been reported with interactive digital books or ebooks (Pykhtina et al., 2012). Ebooks also open doors to the use of new sensors. This work focuses on an innovate use of a color-depth (RGB-D) camera to incorporate video self-modeling into ebook reading.

Pykhtina, O. et al. (2012). Magic land: play therapy on interactive tabletops. In *Proceedings of the 2012 ACM annual conference extended abstracts on Human Factors in Computing Systems* (CHI EA '12). ACM, New York, NY, USA, 2429-2434.

BACKGROUND

Current ebook technology is at its infancy and the possibilities of incorporating cutting-edge visualization and sensing to deliver meaningful digital storybook intervention are virtually limitless.

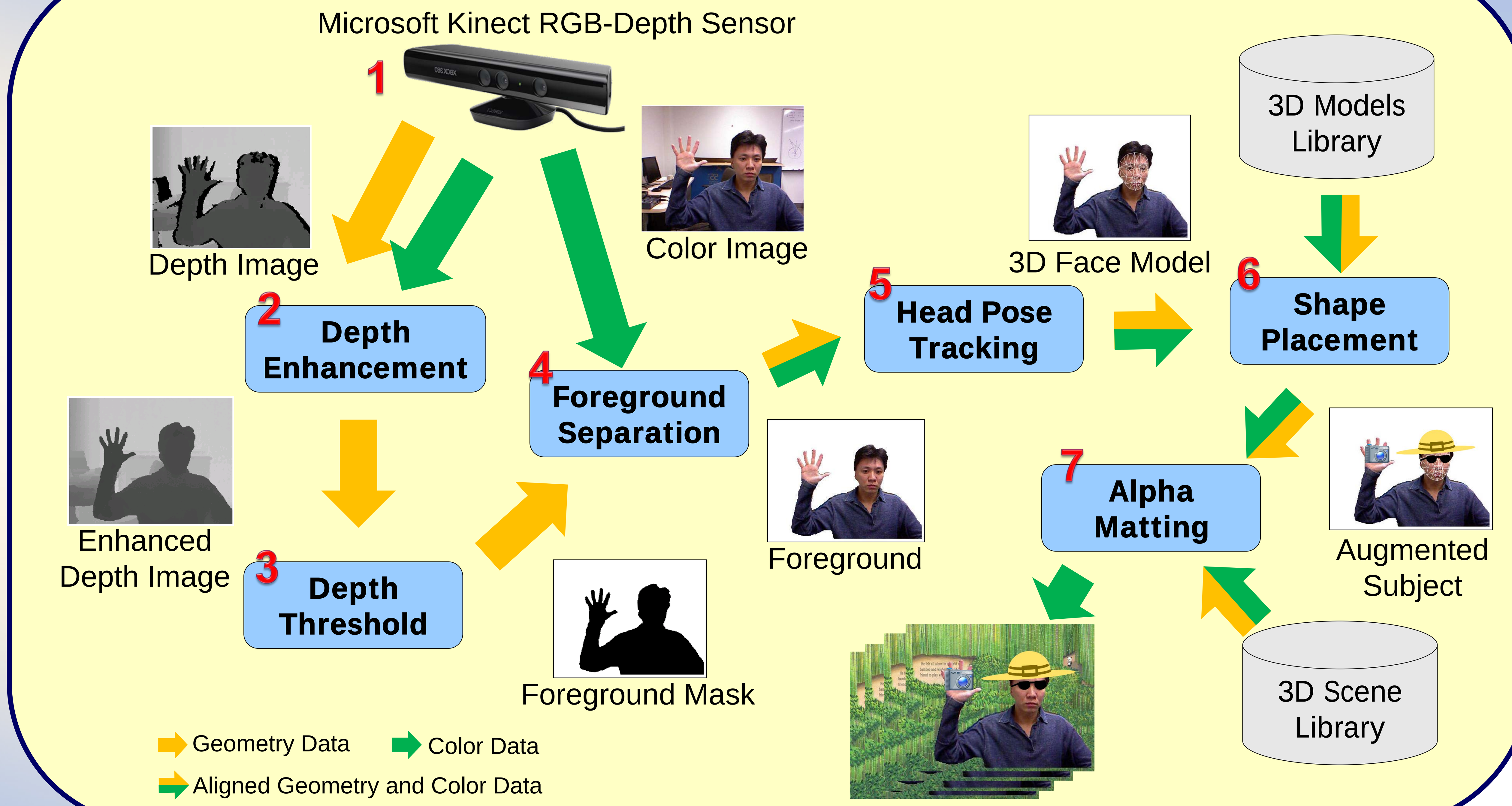
Self-modeling is the use of self images in a visual sequence in order to teach or enhance a certain behavior. Video self-modeling (VSM) has been demonstrated to be effective in various learning tasks for children with ASD (Buggey 2009).

Akin to VSM where a child is recorded performing a desired activity, our hypothesis is that **by portraying a child as a character in a story, a child's self-regulation while reading storybook will increase**.

Rather than passively reading a story, we hope that visualizing one-self in the story provides a suitable model in engaging the reader in understanding the story and promoting self-regulatory activities during reading.

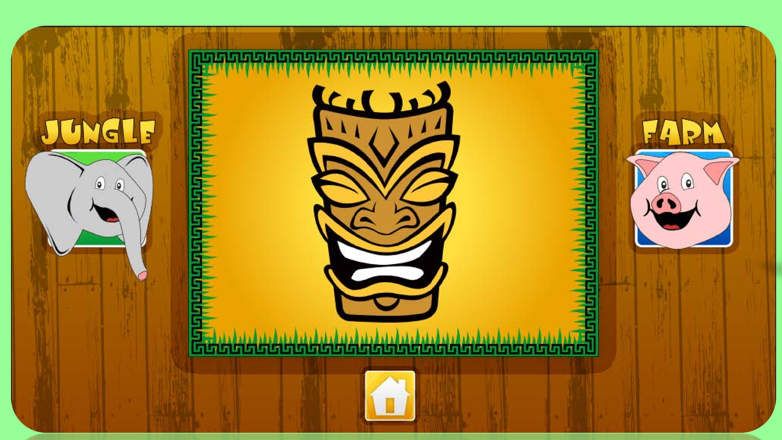
Buggey, T. (2009). *Seeing Is Believing: Video Self Modeling for people with Autism and other developmental disabilities.* Woodbine House, 2009.

MEBOOK TECHNOLOGY

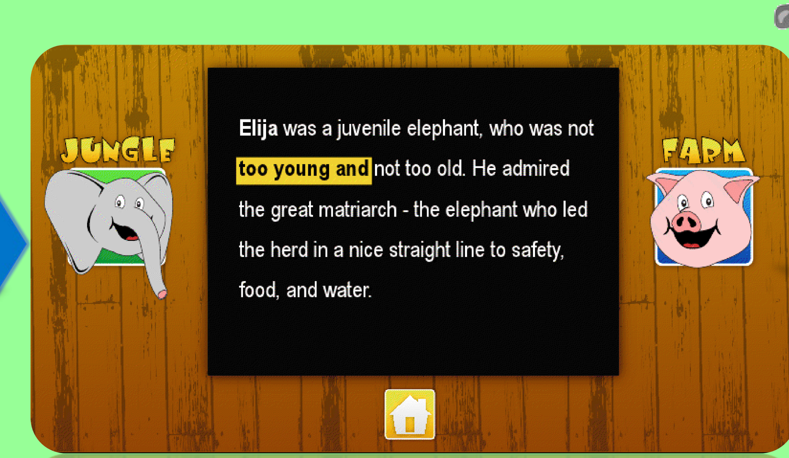


MEBOOK INTERFACE

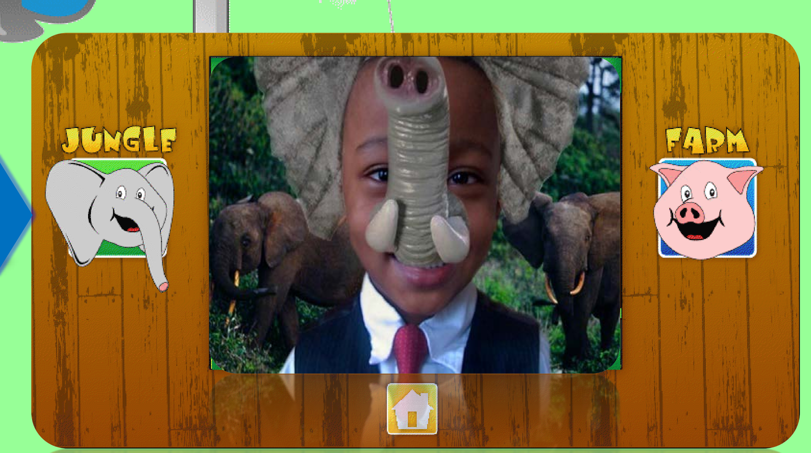
Setup of Computer and Kinect



At the home screen, a reader can choose from a number of stories.



A narrator reads one page of the story and asks the reader to read along.



A 3D scene appears with the live-feed video of the reader morphed into one of the story characters.

MEBOOK INTERVENTION

We adopt the Social Cognitive perspective in our intervention, which takes a process viewpoint to self-regulation - a person can be induced to apply self-regulatory strategies for a task (Zimmerman, 2000).

Initial evaluation will involve a small group of typically-developed students in a usability test. These observations will help us make modifications of the MEBOOK design.

Then, using a pre-test post-test experimental design, we will conduct our formal evaluation on 10 children 6 to 12 years of age with a diagnosis of autism. As pre-test, we will conduct tests on children's reading accuracy and comprehension using standardized tests such as Neale Analysis of Reading Ability.

For the post-test, we will evaluate their comprehension of the story, and their recognition of words and features in the book. These scores will be compared to norms available to assess their comprehension level and see if they are higher or lower and these comparisons of the effectiveness of digital interventions against standards.

Zimmerman, B. (2000). Attaining self-regulation: A social cognitive perspective. M. Boekarts, P. Pintrich, M. Zeidner, eds. *Handbook of Self-Regulation, Academic Press*, San Diego, 1339

CONCLUSIONS

We have designed a software application, MEBOOK, to enhance digital story books with interactive visualization tools, making them suitable for children with ASD. The novelty is the use of the child's face as a character in the story, a form of self-modeling, to engage the child in the story. A subsequent study to measure the effectiveness of MEBOOK in enhancing comprehension and self-regulation in reading among 6-12 years old children with ASD is underway.

Acknowledgments:
The authors would like to thank Dr. Radhika Santhanam for her help in designing the ebook intervention study, and the financial support from the National Science Foundation under Grant No. 1237134.

Layer Depth Denoising and Completion for Structured-Light RGB-D Cameras

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Introduction

Depth images obtained by a typical structured-light stereo RGB-D system, such as Microsoft Kinect, have two major problems: missing and distorted depth values, which can significantly degrade the performance of any subsequent vision processing. As Figure 1 shows, all the black regions in the depth image contain no depth measurements.

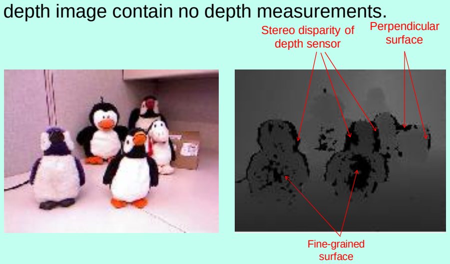


Fig. 1. A pair of typical depth and RGB images obtained by Kinect

Technical Contributions

- Propose a new **graphical model** that jointly models **correlation between color and depth pixels** from RGB-D cameras.
- **Segment** the noisy depth image into a number of **dynamically-determined depth layers** through a combination of
  - i. Background subtraction
  - ii. Depth homogeneity
  - iii. Spatial color homogeneity
  - iv. Surface Normal
- **Denoise each depth layer** through **outlier depth pixel removal** with RANSAC, and **pixel interpolation** with a joint color and depth bilateral filter.

Overview of Approach

We proposed a stochastic framework that automatically separates the depth image into multiple layers, and combines multiple RGB-D system noise models to robustly determine the depth layer label. The depth denoising and completion are steered by the layers that can better preserve object boundary and prevent noise propagation across objects with significant depth differences.

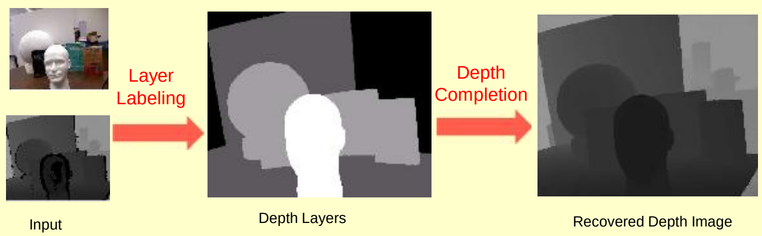


Fig. 2. Depth denoising and completion Workflow

Color-Depth Modeling

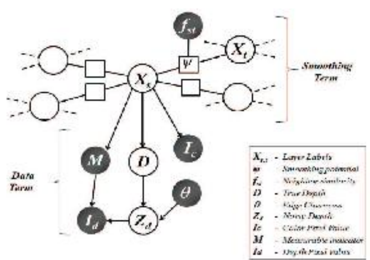


Fig. 3. MRF model

The depth layer labeling is solved as a maximum a-posteriori estimation problem, and a Markov Random Field attuned to the uncertainty in measurements is used to spatially smooth the labeling process.

The MRF parameter estimation is summarized in Figure 4, where foreground and background separation is obtained in the first step. Then multiple layers are further adapted dynamically according to the depth distribution.

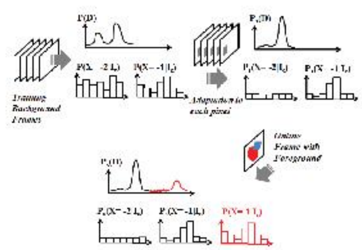
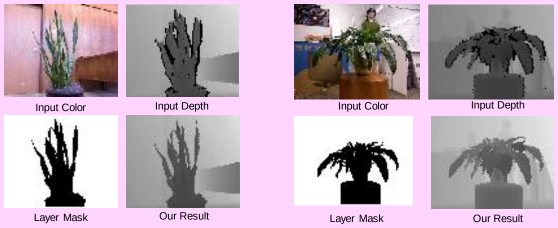


Fig. 4. Parameter estimation diagram

Our Results

Thin objects



Compared to other works: