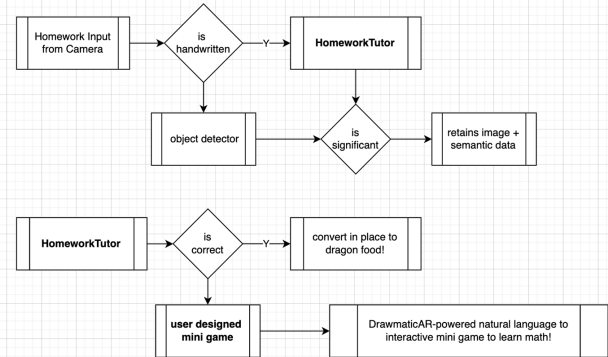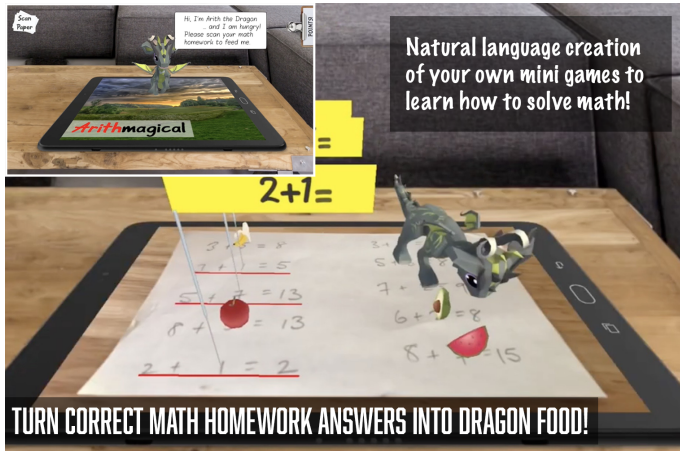# Arithmagical: Magical Platform Technology Towards a Strong AI Virtual Tutor

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ABSTRACT

Arithmagical is an iOS/Android/Chrome app that lets you feed your real math homework to a virtual magical dragon, where AI turns correct answers into dragon food and incorrect answers into mathemagical adventures, with UX that exposes AR themes and seamless non-intrusive computer vision capture in a way accessible to toddlers (with shaky hands and short attention spans). Virtual pet emotional-connection interactivity, memory retention and additional open-ended AI-guided game creation generalize this towards a strong AI virtual tutor platform.

CCS CONCEPTS

• **Software and its engineering** → **Designing software**; • **Human-centered computing** → **Human computer interaction (HCI)**; **Mixed / augmented reality**; **Natural language interfaces**; Graphical user interfaces; *Web-based interaction*; Virtual reality; *Interaction design*; **Ubiquitous and mobile computing**; **Ubiquitous and mobile devices**; *Smartphones*; **Personal digital assistants**; *Tablet computers*; *Mobile devices*; *Handheld game consoles*; Accessibility; • **Applied computing** → **E-learning**; **Computer-managed instruction**; **Interactive learning environments**; • **Computing methodologies** → *Natural language processing*; *Natural language generation*; *Speech recognition*; *Information extraction*; *Computer vision*; *Computer vision tasks*; *Mobile agents*; • **Computer systems organization** → **Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability;

KEYWORDS

virtual pet, multi-purpose computer vision, NLP, AI tutor, cross-platform AR UX accessibility

1 PLATFORM MECHANICS

1.1 Main Overview

The user takes a photo of their homework (anything written on paper), and the AI system interacts appropriately. We utilize AI-trained image to text to convert any input image into text, for the system to process through different AI tutor interactions.

We imagine a current generation strong-ish AI virtual tutor to possess the ability to interact with the user in an open-ended creative way. Beyond utilizing the usual tactics of virtual pet elements, we allow the user to co-design with the AI the type of mini game the user would like to play.

1.2 Arithmagical (+): "Do your math homework correctly to feed your magical dragon!"

In the inaugural edition launched on the App Store and Play Store earlier this year, we focus Arithmagical (+) in a subject-specific version on simple addition for an ages 3 to 6 age group. To naturally answer the most common question, such a user would ask when told to do their math homework, "But why do I have to do my math homework," with the universally placating, "To feed your magical virtual dragon pet," the system will convert correct answers into dragon food. Incorrect answers will prompt the AI tutor to launch user-created mini-games, similar to how a real tutor would try to drill homework in a fun way to users in this age group.

1.3 Subsystem Computer Vision Onboarding

Handwriting, particularly, children's handwriting recognition by machines has traditionally been problematic, but recent advances in ML models have created better-trained models, as shown in DrawmaticAR [Chang 2020].

In addition, for the case where a user were to take a photo of an arbitrary image, object recognition can be utilized for the AI tutor to strike a meaningful conversation with the user, as explained later.

In addition, we can also apply additional reality-bridging magical capacity, via techniques from previous real paper to 3D AR projects [Chang and Grandhi 2019] and [Chang 2019b].

1.4 Subsystem AI Tutor

Similar to what a real tutor would do, our AI tutor helps the user learn from their mistakes and rewards the user for their correct answers. (In this case, the rewards just happen to be virtual sustenance to feed the AI tutor as a virtual pet!)

1.5 Subsystem AI Mini-Games

The mini-game collection is powered by a series of common games one learns math from, which the internal GAN mini-game engine can use to create even more mini-games.

Utilizing a subset of the AI from our SIGGRAPH Real-Time Live-winning DrawmaticAR [Chang 2020], we implement an experimental open-ended natural-language input game creation system that lets children without any programming experience "program" their own mini-games. This is similar to how a real life tutor may invent different types of games, or bring different kinds of learning tools for different clients, in addition to also having a subset of their own.

We also utilize image to 3D model GANs, so that if a user were to send a photo of an object that they would like to see in a virtual mini game, we could auto-magically accomodate as in the author's Worldmatica demo [Chang 2022].

1.6 Subsystem Lifestyle Integration

Because the underlying system is intrinsically a virtual agent, the system can also interact with additional elements input by the user. For example, if the user were to take a photo of a dog, instead of their math homework, the AI tutor would comment appropriately, and also, if (for example) the user specifies that this is their dog,

would retain the memory appropriately. (Internally, we identify the dog breed and semantically segment background extract it similar to the author's Dog Eye It app [Chang 2019a]).

2 VIRTUAL PET FEATURES ADAPTED FOR EDUCATION

Unlike the author's previous AR math education app platform PlatoAR[Chang 2015], which focused on conceptual geometry education on magical graph paper, the focus of Arithmagical is primarily on drilling and learning from mistakes - this is effectively what a math tutor helps with. Aspects of virtual pet app design, such as in the author's GiftGAMI[Chang 2016] (you can use touch gestures to poke, tickle, etc the AR pet), ARKitty[Chang 2017a], AlexaPet[Chang 2017b] and Ozimals/HB Bunny (Second Life)[as Ina Centaur 2008], are used in prompting for regular drilling. For example, the pet will demand more food, or its health and happiness metrics may decrease.

3 "FRIENDLY AR": PLATFORM AND TARGET USER EXPERIENCE DESIGN CONSIDERATIONS

Instead of requiring that the user continuously hold the device pointed at their paper homework, while interacting with the app, the user needs to take simply a single photo. This is in-nature with transparent interface design, utilizing calm technology principles [Case 2015], to avoid hand strain from holding the device, and to allow the user to focus on learning instead of worrying about holding for augmentation. It also makes sense within the magical paradigm of our app platform, as effectively, our AI tutor lives in a digital space where interaction with the real world happens only when the user opts-in by taking a photo. The appearance of augmentation happens, of course, in our virtual environment that then becomes mixed with the user's captured "homework photo", which also naturally gives way to a wealth of virtual items to reward the user with!

REFERENCES

Yosun Chang as Ina Centaur. 2008. *Ozimals and HB Bunny Second Life virtual pets*. Second Life, San Francisco, CA.

Amber Case. 2015. *Calm technology: principles and patterns for non-intrusive design.* " O'Reilly Media, Inc.".

Yosun Chang. 2015. *PlatoAR*. AReality3D, San Francisco, CA. https://www.PlatoAR.com/

Yosun Chang. 2016. *PlatoAR*. AReality3D, San Francisco, CA. https://www.GiftGAMI.com/

Yosun Chang. 2017a. *PlatoAR*. AReality3D, San Francisco, CA. https://www.ARKitty.com/

Yosun Chang. 2017b. *TinyFox for AlexaPet*. AReality3D, San Francisco, CA. https://www.AlexaPet.com/

Yosun Chang. 2019a. *Dog Eye It*. AReality3D, San Francisco, CA. https://devpost.com/software/dogeye

Yosun Chang. 2019b. *faced.io SUR: sur.faced.io: augmented reality content creation for your face and beyond*. AReality3D Permute.xyz AIMagical, Newport Beach, CA. https://sur.faced.io/

Yosun Chang. 2020. *DrawmaticAR: Automagical Content Creation thru Written Words*. AReality3D Permute.xyz AIMagical, Newport Beach, CA. https://www.drawmaticAR.com/

Yosun Chang. 2022. *Worldmatica*. AReality3D Permute.xyz, San Francisco, CA. https://www.youtube.com/watch?v=DoekAbOj4Ns

Yosun Chang and Uttam Grandhi. 2019. *PlayGAMI: augmented reality origami creativity platform*. AReality3D Permute.xyz, New York, NY. https://www.playgami.com/