KEYAN ZHAI

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My research interests lie at the intersection of CV, CG and Robotics, with a focus on the perception, modeling, and understanding of the 3D world. I am particularly excited about topics such as **3D/4D reconstruction**, **neural rendering**, **sensor fusion**, **visual odometry**, etc. My ultimate aim is to digitize humans, objects and events in the physical world and explore their applications in industries like AR/VR, autonomous driving and Robotics.

EDUCATION

University of Pennsylvania   *Sep 2021 - May 2023*
*M.S.E. in **Robotics**, School of Engineering and Applied Science, **GPA: 3.81/4***

ShanghaiTech University   *Sep 2017 - Jul 2021*
*B. Eng. in **Computer Science and Technology**, School of Information Science and Technology*

TECHNICAL SKILLS

Languages	Python, C, C++, Java, Rust, HTML, CSS, JavaScript, TypeScript, PHP, SQL, Matlab
Frameworks	NumPy, Pandas, PyTorch, scikit-learn, Matplotlib, OpenCV, OpenGL, Qt, Django, Laravel
Tools	Git, Jenkins, Linux, Shell, CMake, GDB, Valgrind, Docker, AWS, ROS, GoogleTest, Postman

WORK EXPERIENCE

Apple Inc. - Technology Development Group   *May 2022 - Aug 2022*
Software Engineer / CVML Intern - AR/VR Algorithm Infrastructure   *Sunnyvale, California*

· Contributed to a large-scale library codebase (**2m+** lines) including **computer vision**, **computer graphics**, and **deep learning** algorithms used by AR/VR algorithm researchers with **C**, **C++**, and **CMake**

· Optimized multiple **applications** and **unit tests** for **App Clip Codes** [**Link**], achieving a **60%** speed improvement and removal of dependency on testing resource files, saving **100%** disk space

· Created and automated a comprehensive **test pipeline** for App Clip Codes, encompassing multiple phases including **image rendering** and **processing**, resulting in a **50%** reduction in manual testing steps

· Strengthened the **video processing application** by enabling visualization and restructuring the **concurrent dataflow** of multi-track video replay pipeline, facilitating issue identification for future debugging and feature development

· Streamlined the software development cycle by refactoring library **API**s to a **production-level** with uniformed standards, ensuring best code practices and enabling efficient validation of code quality by the Quality Assurance team

Vijay Kumar Lab - GRASP Lab, University of Pennsylvania   *Jan 2022 - May 2022*
Software Engineer - Simulation Infrastructure   *Philadelphia, Pennsylvania*

· Configured **full-stack** simulations of **large-scale** multi-robot systems with more than 60 robots using **Unity** and **ROS**; developed simulation software infrastructures in **Python** and **C++/CMake** with multiple **Docker** containers

· Streamlined the development workflow of cutting-edge **robotic control and planning algorithms** by restructuring them to a common interface, facilitating simplified use of the simulator for researchers across various universities

Living Machines Laboratory, ShanghaiTech University   *Jul 2020 - Jan 2021*
Undergraduate Researcher   *Shanghai, China*

· Built a legged robot [**Link**] equipped with **IMU** and **strain gauge** on **Arduino** using **Solidworks** and **3D printing**

· Designed and implemented an **optimization algorithm** based on **Bayesian Optimization** with **Python** and applied the algorithm to the control system of the legged robot, increasing weight support by **5.54%** compared to baseline

· Presented **publication** [**Link**] as the **first author** at 16th International Conference on Intelligent Autonomous Systems

Shanghai Center for Brain Science and Brain-Inspired Technology   *Jul 2019 - Apr 2020*
Software Engineer Intern - Cognitive AI Group   *Shanghai, China*

· Developed an online IQ test **web application** [**Link**] that allows IQ test for both human and machine with **Python**, **Django** and **SQLite** for the first Machine Automated IQ Test Challenge (MAIQ) at **IJCAI-2020** [**Link**]

· Curated test **dataset** with **700+** IQ test problems including verbal comprehension, diagram reasoning and sequence reasoning; automated **dynamic generation of image dataset** with hierarchical representation of test images

RESEARCH PUBLICATION

<u>**K. Zhai**</u>, C. Li, and A. Rosendo, "Scaffolded Learning of In-place Trotting Gait for a Quadruped Robot with Bayesian Optimization," 16-th International Conference on Intelligent Autonomous Systems. [**Link**]

COMPUTER VISION PROJECTS

3D Scene Reconstruction from 2D viewpoints   **Python/NumPy/Computer Vision**

· Implemented **two-view stereo** and **plane-sweep multi-view stereo algorithm** that utilizes 5 different views to convert multiple 2D viewpoints into a **3D reconstruction** of the scene

Augmented Reality App with AprilTags   Python/NumPy/Computer Vision

· Implemented an **AR application** that shows several virtual object models in a given video with AprilTags by solving **PnP** with coplanar assumption and solving **P3P** with the **Procrustes** problem

Face Swapping in Two Videos [Link]   Python/NumPy/OpenCV

· Built a pipeline that can **detect and swap faces** seamlessly in two videos, including **feature detection** and **extraction**, **optical flow** to track faces, **image morphing**, and **Poisson blending** to make the face swapping natural

Automated Fall Risk Assessment with 3D Human Pose Estimation [Link] [Demo]   Python/OpenCV

· Developed an application based on 3D Human Pose Estimation to automatically test the risk of falling for the elderly; improved joint positional accuracy with optical flow and **sensor fusion** using Unscented Kalman Filter with IMU data

MACHINE LEARNING / DEEP LEARNING PROJECTS

COVID Classification with CNN [Link]   Python/PyTorch/NumPy/Pandas

· Created a **dataset** of **2,500** chest X-ray images for classification between COVID and normal lungs; trained a **CNN** model with pretrained **resnet18 backbone**, reaching test accuracy of **93%**

Perceiving Music Quality with various ML models [Link]   Python/PyTorch/AWS

· Created a new training **dataset** of **1950** music segments and applied different types of audio degradation on them; trained **supervised learning models** (**SVM** and **CNN**) on the created dataset to predict the audio quality and evaluated the performance **quantitatively** compared with existing methods

COMPUTER GRAPHICS PROJECTS

Mini Minecraft [Link]   C++/OpenGL/Qt/OOP/Computer Graphics

· Created an **interactive 3D** world exploration and alteration Minecraft-style program including a **controllable Player** class with **simple physics** that includes player control, velocity, acceleration, position change, and collision checking

· Implemented **procedural generation** of terrain and cave systems using **noise functions** such as **Perlin** and **FBM**, enabling efficient terrain rendering, chunking and distance-based loading with **multi-threading** techniques

· Expanded upon the existing **lambert shader** to allow for **UV texture mapping** with provided textures

Micro Maya Mesh Editor   C++/OpenGL/Qt/OOP/Computer Graphics

· Developed a mesh editor application in **C++** including the half-edge mesh data structure and visualization with **OpenGL** that supports Catmull-Clark subdivision, loading and rendering OBJ files, and binding meshes to skeletons

3D Rasterizer   C++/OpenGL/Qt/OOP/Computer Graphics

· Created a **rasterizer** for both 2D and 3D scenes in **C++** and programmed **OpenGL**'s graphics pipeline including vertex and fragment **shaders** to apply different coloration effects to the surfaces of **3D models**

ROBOTICS PROJECTS

PANDA Arm Pick-and-Place   Python/NumPy/ROS

· Implemented **Inverse Kinematics** based on **iterative optimization** with **gradient descent** and **planning algorithms** like **Astar** and **RRT** for the **7-DoF** Franka Emika PANDA robot arm, enabling the robot to pick, place, and stack both **static** and **dynamic** blocks **fully autonomously**

Point-Cloud Based Stair Climbing of MIT Mini Cheetah [Link]   C++/Python

· Collected 3d **point cloud** data of stairs using **LiDAR** and built traversability map models; modified the **gait control algorithms** based on the map models to improve the performance of stair climbing for MIT Mini Cheetah

Autonomous Elevator Robot [Link]   C++/ROS

· Enabled a mobile robot with a manipulator to take elevators autonomously by detecting and pressing buttons; applied **AMCL** for localization, **OCR-RCNN** for button detection, and **MoveIt!** for motion planning of the manipulator

COMPUTER SYSTEMS PROJECTS

PennOS, a UNIX-Like Operating System   C/Linux/Operating System

· Developed a UNIX-like operating system including a **priority scheduler**, **FAT file system**, and **user shell**

· Contributed to development of the **kernel** which supports **process creation**, **process scheduling** with **priorities**, **signaling**, and integrated a **shell** that supports **job control**, **redirections**, and a functional set of **built-in commands**

The Sniper Multi-Core Simulator   C++/Computer Architecture

· Modified the **cache subsystem** of a multi-core x86 simulator Sniper to achieve **optimal replacement policy** that can be used by any level of CPU cache; implemented a perceptron-based **dynamic branch prediction** algorithm; conducted configuration and quantitative evaluation of **MSI**, **MESI**, and **MESIF cache coherency** protocols