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General Article

Google Project Tango – A Convenient 3D Modeling Device

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Abstract

The goal of Project Tango is to create technology that lets you use mobile devices to piece together three-dimensional maps, thanks to an array of cameras, depth sensors and clever algorithms. It is Google's way of mapping a room interior using an Android device. 3D technology is the future of mobile. With the growing advent of 3D sensors being implemented in phones and tablets, various softwares will be an app enabling millions of people to engage, interact and share with the world around them in visually rich 3D.

Keywords: *Project Tango, three-dimensional maps, 3D sensor.*

1. Introduction

3D models represent a 3D object using a collection of points in a given 3D space, connected by various entities such as curved surfaces, triangles, lines, etc. Being a collection of data which includes points and other information, 3D models can be created by hand, scanned (procedural modeling), or algorithmically. The "Project Tango" prototype is an Android smartphone-like device which tracks the 3D motion of particular device, and creates a 3D model of the environment around it.

The team at Google’s Advanced Technology and Projects Group (ATAP). It has been working with various Universities and Research labs to harvest ten years of research in Robotics and Computer Vision to concentrate that technology into a very unique mobile phone. We are physical being that live in a 3D world yet the mobile devices today assume that the physical world ends the boundaries of the screen. Project Tango’s goal is to give mobile devices a human-scale understanding of space and motion. This project will help people interact with the environment in a fundamentally different way and using this technology we can prototype in a couple of hours something that would take us months or even years before because we did not have this technology readily available. Imagine having all this in a smartphone and see how things would change.

This device runs Android and includes development APIs to provide alignment, position or location, and depth data to regular Android apps written in C/C++, Java as well as the Unity Game Engine(UGE). These early algorithms, prototypes, and APIs are still in active development. So, these are experimental devices and are intended only for the exploratory and adventurous are not a final shipping product.

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2. Description

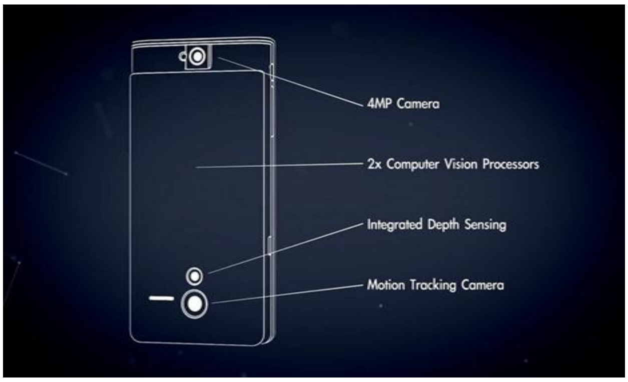

Fig.1 Model of Google’s Project Tango

Project Tango is a prototype phone containing highly customized hardware and software designed to allow the phone to track its motion in full 3D in real-time. The sensors make over a quarter million 3D measurements every single second updating the position and rotation of the phone, blending this data into a single 3D model of the environment. It tracks ones position as one goes around the world and also makes a map of that. It can scan a small section of your room and then are able to generate a little game world in it. It is an open source technology. ATAP has around 200 development kits which has already been distributed among the developers.

3. Overview

Google's Project Tango is a smartphone equipped with a variety of cameras and vision sensors that provides a whole new perspective on the world around it. The Tango smartphone can capture a wealth of data never before available to application developers, including depth and object-tracking and instantaneous 3D mapping. And it is almost as powerful and as big as a typical smartphone.

It's also available as a high-end Android tablet with 7-inch HD display, 4GB of RAM, 128GB of internal SSD storage and an NVIDIA Tegra K1 graphics chip (the first in the US and second in the world) that features desktop GPU architecture. It also has a distinctive design that consists of an array of cameras and sensors near the top and a couple of subtle grips on the sides.

Movidius which is the company that developed some of the technology which has been used in Tango has been working on computer vision technology for the past seven years — it developed the processing chips used in Project Tango, which Google paired with sensors and cameras to give the smartphone the same level of computer vision and tracking that formerly required much larger equipment.
The phone is equipped with a standard 4-megapixel camera paired with a special combination of RGB and IR sensor and a lower-resolution image-tracking camera.

These combos of image sensors give the smartphone a similar perspective on the world, complete with 3-D awareness and a awareness of depth. They supply information to Movidius custom Myriad 1 low-power computer-vision processor, which can then process the data and feed it to apps through a set of APIs. The phone also contains a Motion Tracking camera which is used to keep track of all the motions made by the user.

Fig.2 Front and Rear Camera **Fig.3** Fish-eye lens

3.1 The Motherboard

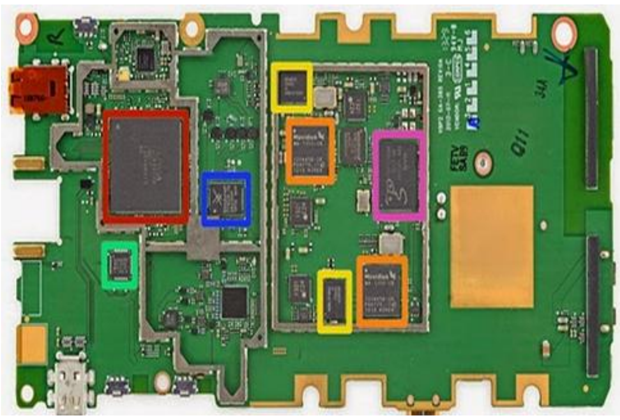

Fig.4 Motherboard

The figure above is the motherboard: the red is 2GB LPDDR3 RAM, along with Qualcomm Snapdragon 800 CPU, the orange is computer image processor Movidius Myriad 1, the green which contain 9-axis acceleration sensor / gyroscope / compass, motion tracking, the yellow is two memory ICs AMIC A25L016 flash 16Mbit, the purple is the SoC 3D sensor PrimeSense PSX1200 Capri PS1200, the blue is SPI flash memory Winbond W25Q16CV 16Mbit. Internally, the Myriad 2 consists of 12 128-bit vector processors called Streaming Hybrid Architecture Vector Engines, or SHAVE in general, which run at 60MHz. The Myriad 2 chip gives five times the SHAVE performance of the Myriad 1, and the SIPP engines are 15x to 25x more powerful than the 1st generation chip. The SHAVE engines communicates with more than 20 Streaming Image Processing Pipeline engines, which serve as hardware image processing accelerators.

4. Main Challenges

The main challenge faced with this technology was to select and transfer appropriate technologies from a vast research space already available into a tough, resourceful product ready to be shipped on a mobile phone or a tablet. This is an incredibly formidable task. Though there has been research in the domain, most Simultaneous Localization and Mapping (SLAM) software today works only on high powered computers, or even massive collections of machines. Project Tango, in contrast, requires running a significant amount of mapping infrastructure on the phone or a tablet itself to provide real-time reaction to users. This introduces two discrete challenges. We must carefully manage both our power, size and CPU budgets.

5. Working

5.1 The Camera

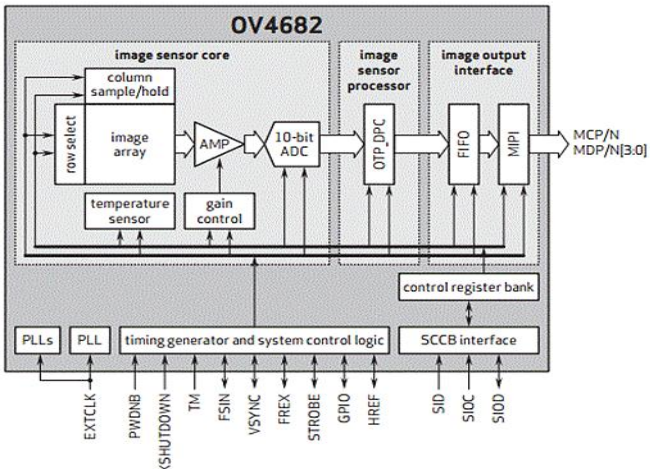

Fig.5 Block Diagram of the camera

As the main camera, the Tango uses OmniVision's OV4682. It is the eye of Project Tango's mobile device. The OV4682 is a 4MP RGB IR image sensor that captures high-resolution images and video as well as IR information, enabling depth analysis. The sensor features a 2um OmniBSI-2 pixel and records 4MP images and video in a 16:9 format at 90fps, with a quarter of the pixels dedicated to capturing IR. The sensor's 2-micron OmniBSI-2 pixel delivers excellent signal-to-noise ratio and IR sensitivity, and offers best-in-class low-light sensitivity with a 40 percent increase in sensitivity compared to the 1.75-micron OmniBSI-2 pixel. The OV4682's unique architecture and pixel optimization bring not only the best IR performance but also best-in-class image quality. Additionally, the sensor reduces system-level power consumption by optimizing RGB and IR timing.

The OV4682 records full-resolution 4-megapixel video in a native 16:9 format at 90 frames per second (fps), with a quarter of the pixels dedicated to capturing IR. The 1/3-inch sensor can also record 1080p high definition (HD) video at 120 fps with electronic image stabilization (EIS), or 720p HD at 180 fps. The OV7251 Camera Chip sensor is capable of capturing VGA resolution video at 100fps using a global shutter.

5.2 Image and depth Sensing

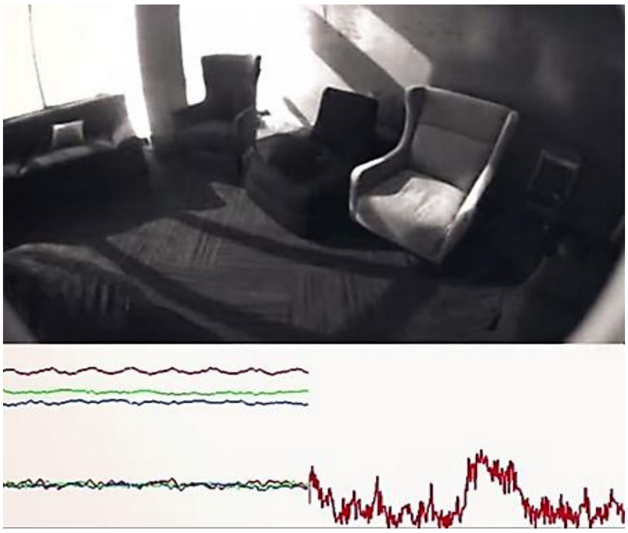

Fig.6 Feed from fish-eye lens.

In the figure given above, the image represents the feed from the fish-eye lens.

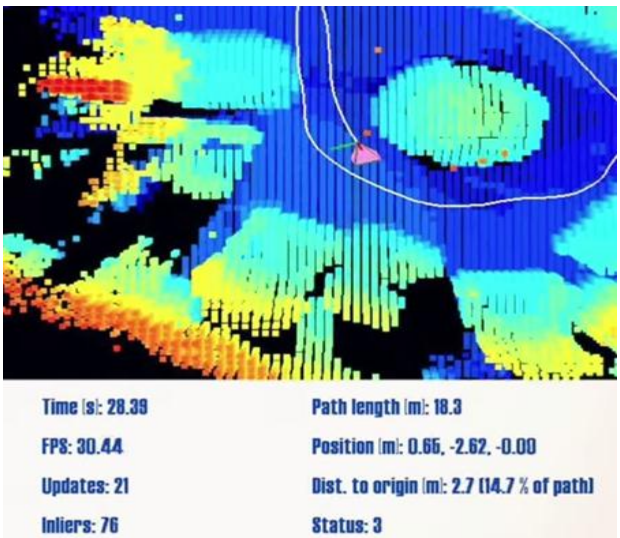

Fig.7 Computer vision

And in the image above the green dots basically represents the computer vision stack running. So if the users moves the devices left or right, it draws the path that the devices and that path followed is show in the image on the right in real-time. Thus through this we have a motion capture capabilities in our device. The device also has a depth sensor. The figure above illustrates depth sensing by displaying a distance heat map on top of what the camera sees, showing blue colors on distant objects and red colors on close by objects. It also the data from the image sensors and paired with the device's standard motion sensors and gyroscopes to map out paths of movement down to 1 percent accuracy and then plot that onto an interactive 3D map. It uses the Sensor fusion technology which combines sensory data or data derived from sensory data from disparate sources such that the resulting information is in some sense better than would be possible when these sources were used separately. Thus it means a more precise, more comprehensive, or more reliable, or refer to the result of an emerging view, such as stereoscopic vision

5.3 3D Mapping

MV4D technology by Mantis Vision currently sits at the core of the handheld 3D scanners and works by shining a grid pattern of invisible lights in front of a bank of two or more cameras to capture the structure of the world it sees – not entirely unlike what you see when putting in a Tiger Woods game.

HiDOF, meanwhile, focuses in software that can not only read the data that the sensor produces, but also combine it with GPS, gyroscope, accelerometer and readings to produce an accurate map of your immediate surroundings in real-time.

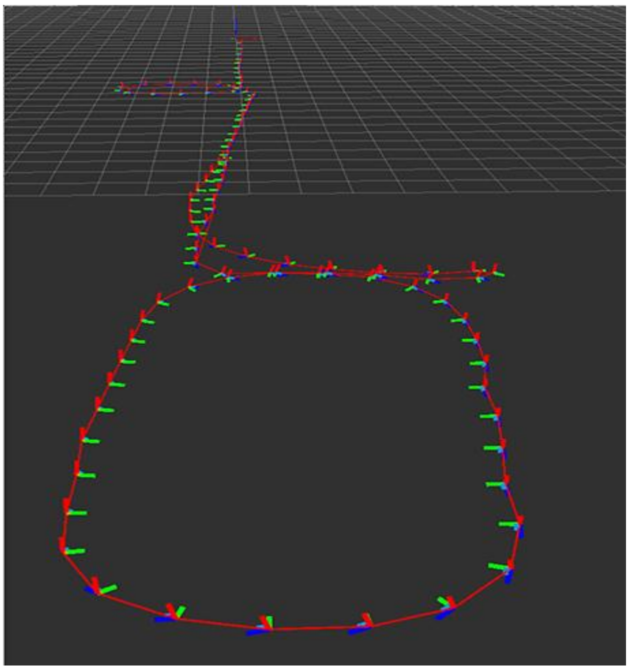

Fig.8 Visual sparse map

Over the last year, hiDOF has applied its knowledge and expertise in the SLAM (Simultaneous Localization and

Mapping) and technology transfer spaces to Project Tango. It generates realistic, dense maps of the world. It focuses to provide reliable estimates of the pose of a phone i.e. position and alignment, relative to its environment, dense maps of the world. It focuses to provide reliable estimates of the pose of a phone (position and alignment), relative to its environment.

The figure above represents the visual sparse map as viewed through hiDOF's visualization and debugging tool. Simultaneous localization and mapping (SLAM) is a technique used by digital machines to construct a map of an unknown environment (or to update a map within a known environment) while simultaneously keeping track of the machine's location in the physical environment. Put differently, "SLAM is the process of building up a map of an unfamiliar building as you're navigating through it—where are the doors? where are the stairs? what are all the things I might trip over?—and also keeping track of where you are within it.

The SLAM tool used for mapping consists of the following:

- A real-time, on device, Visual Inertial Odometer system capable of tracking the position (3D position and alignment) of the device as it moves through the environment.
- A real-time, on device, complete 6 DOF SLAM solution capable of adjusting for odometry drift. This system also includes a place recognition module that uses visual features to identify areas that have been previously visited. It also includes a pose graph non-linear optimization system used to correct for drift and to readjust the map on loop closure events.
- A compact mapping system capable of taking data from the depth sensor on the device and building a 3D reconstruction of the stage.
- A re-localization structure built on top of the place recognition module that allows users to regulate their position relative to a known map.
- Tools for sharing maps among users, allowing users to operate off of the same map within the same environment. Thus, this opens up the possibility of collective map building.
- Arrangement for monitoring progress of the project, testing algorithms, and avoiding code worsening.

Future Scope

Project Tango seeks to take the next step in this mapping evolution. Instead of depending on the infrastructure, expertise, and tools of others to provide maps of the world, Tango empowers users to build their own understanding, all with a phone. Imagine knowing your exact position to within inches. Imagine building 3D maps of the world in parallel with other users around you. Imagine being able to track not just the top down location of a device, but also its full 3D position and alignment. The technology is ambitious, the potential applications are powerful.

The Tango device really enables augmented reality which opens a whole frontier for playing games in the scenery around you. You can capture the room, you can then render the scene that includes the room but also adds characters and adds objects so that you can create games that operate in your natural environment. The applications even go beyond gaming. Imagine if you could see what room would look like and decorate it with different types of furniture and walls and create a very realistic scene. This Technology can be used the guide the visually impaired to give them auditory queues or where they are going. Can even be used by soldiers in war to replicate the war-zone and prepare for combat or can even be used to live out one's own creative fantasies. The possibilities are really endless for this amazing technology and the future is looking very bright.

Conclusion

At this moment, Tango is just a project but is developing quite rapidly with early prototypes and development kits already distributed among many developers. It is all up to the developers now to create more clever and innovative apps to take advantage of this technology. It is just the beginning and there is a lot of work to do to fine-tune this amazing technology. Thus, if Project Tango works - and we've no reason to suspect it won't - it could prove every bit as revolutionary as Maps or earth or android. It just might take a while for its true genius to become clear

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