AP068
FPGA Based Sensor Hub For VR|AR Application

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Outline

● Motivation
● Introduction
● Features
  1. Head Position Tracking
  2. Eye Tracking
  3. Stereo Vision
● Implementation
● Application
Motivation

● New way to deliver content and experience
● Demand for affordability and portability
● Exponential growth of the industry
● Basic requirements for VR/AR
  ○ Head tracking
  ○ Stereoscopic displays
● Advance requirements
  ○ Eye tracking
  ○ Depth map
Introduction

- FPGA based sensor hub
- 3 main functions
  - Head Position Tracking
  - Stereo Vision
  - Eye Tracking

Initial Measurement Unit (IMU)

Input: Raw acceleration and angular velocity data

Process: Kalman Filter

Result: Head Position Tracking

DE10-Nano

USB

Input: 2D videos

Process: Stereo Vision

Result: Depth Map

Dual Camera

Process: Stereo Vision

Result: Eye Tracking
Features - Head Position Tracking

- Track the direction where user’s head is facing

- Vital data for VR/AR application
- Render specific portion of display based on head position
- Require extra low latency
  - Prevent dizziness
  - Better immersion
Features - Stereo Vision

- Process dual camera images into 3D depth map

- Inside-out tracking
  - Positional tracking based on environment
  - Minimal setup and boundless field

- Realistic augmented/mixed reality
  - Environment aware application
Features - Eye Tracking

- Determine eye position from video stream

- Foveated Rendering
  - Render only portion of the display based on the eye position data.

- Input Interface Device
  - Interaction and control by using eye movement
Head Position Tracking

- Kalman Filtering Algorithm
- Two stages
  - Time prediction
  - Measurement update
- Heavy computation
  - Large block of inputs
  - Complex matrix computation
- FPGA
  - Parallel computation ability
  - Computing resource available
  - Able to configured by end user when necessary
Stereo Vision

● Calibrate and rectify images
  ○ remove distortion
● Grey-scale conversion
● Stereo Matching
  ○ Sum of Absolute Difference (SAD) for cost aggregation
  ○ winner-take-all (WTA) for disparity selection
● Disparity Calculation
  ○ calculate depth from disparity
Eye Tracking

- Using Image Processing Approaches

- Face and Eye Detection
  - Classifier using Viola-Jones Algorithm

- Eye Centre Localisation
  - Image Gradient based
System Architecture

- Uses both FPGA and HPS
  - FPGA
    - Head Position Tracking
    - Stereo Vision
  - HPS
    - Eye Tracking
Applications

- Lightweight, low power sensor hub
  - Integrated with head mounted display

- Provide API to facilitate reading of data from the sensor hub

- Provide hardware abstraction layer
  - Simplify application development for makers and developers
Thank You