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3D Mapping Device for Object Tracking
Progress Review Report

Submitted By:

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Contents

1 Companies in the 3D Mapping Field

1. **Microsoft:** Microsoft has developed the Microsoft Kinect sensor, which utilizes TOF technology for depth sensing. While the Kinect was initially popular in gaming, its applications have extended to various industries, including robotics, healthcare, and augmented reality.

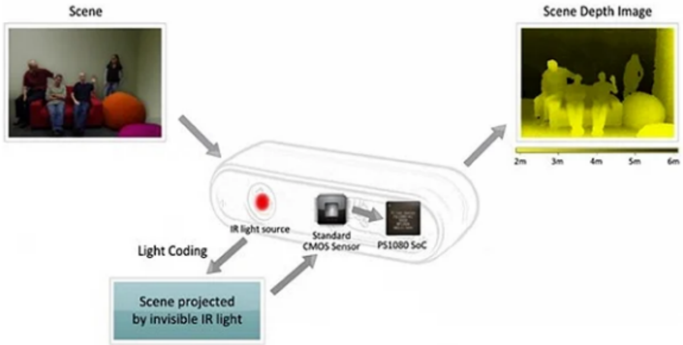

Figure 1: Kinect Sensor

2. **Intel:** Intel has been actively involved in developing TOF sensors for depth sensing applications. Their RealSense series includes TOF cameras suitable for various industrial and consumer applications, including robotics, augmented reality, and 3D scanning.

Figure 2: RealSense

3. **Velodyne:** While primarily known for their lidar sensors for autonomous vehicles, Velodyne has also been exploring TOF technology for short-range applications. They have developed sensors capable of accurate distance measurement and object detection.

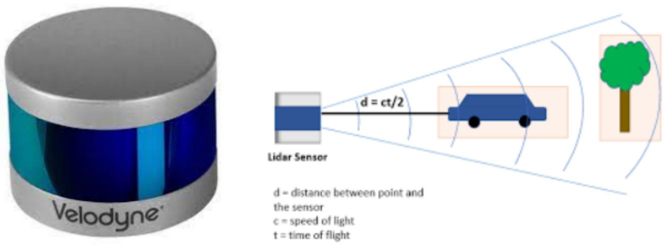

Figure 3: Velodyne

2 Researches Regarding 3D Mapping Technologies

2.1 Research on 3D Digital Map System and Key Technology - Zhao Zhongyuan

This paper discusses the concept, characteristics, and key technologies associated with 3D digital maps, focusing on the case study of the Wuhan 3D digital map system.

Concepts and Characteristics:

- 3D digital maps represent a continuous 3D digital model of a city, serving as the core of 3D digital city construction.
- They integrate various elements such as natural topography, environment, roads, buildings, and infrastructure into a seamless mosaic under a coordinate system.
- These maps leverage technologies like GIS, RS, network, multimedia, and VR to create a multi-dimensional digital city information platform.

Characteristics of 3D Digital Map Systems:

- They create a virtual space environment of the real city, enabling dynamic interactive browsing, spatial analysis, and simulation of large amounts of data.
- They support geographic synergies in network environments, allowing seamless management of urban space and multi-user concurrent access.
- They serve as a 3D space basic platform for city management, providing macro information, and detailed data for various city management activities.

Key Technologies:

- Advanced technologies such as 3DGIS, VR, data compression, computer, and network technologies are employed.

2.2 2D and 3D Object Detection Algorithms from Images: A Survey

This survey provides an overview of the current state and trends in object detection research, focusing on both 2D and 3D object detection algorithms.

Object Detection Overview:

- Object detection, a crucial branch of computer vision, locates and classifies objects in images, encompassing tasks such as object recognition and localization.
- Traditional object detection algorithms relied on hand-designed methods for feature extraction and suffered from limitations such as slow speed, low accuracy, and high computational overhead.

Transition to Deep Learning:

- Deep convolutional neural networks (CNNs) revolutionized object detection by efficiently extracting features from images, leading to significant improvements in speed and accuracy.
- The rise of CNN-based models, such as AlexNet, and Swin Transformer, replaced traditional algorithms and became the mainstream in object detection research.

Recent Advances:

- Recent advancements include the adoption of Transformer models, such as ViT, in object detection, offering dynamic parameter learning mechanisms and improved adaptability to large datasets.
- These developments have sparked research into incorporating Transformers into object detection frameworks as backbone or neck components, further enhancing performance.

Transition to 3D Object Detection:

- While 2D object detection focuses on regressing 2D bounding boxes, the practical needs of real-world applications require 3D object detection to predict detailed information about an object's 3D size, coordinates, speed, and orientation.
- However, transitioning from 2D to 3D object detection presents challenges such as the lack of geometric constraints, and handling multidimensional data.

Importance of 3D Object Detection:

- Despite these challenges, 3D object detection algorithms have gained importance in both industrial and academic communities due to their potential applications in unmanned vehicles, smart robots, and real-time traffic monitoring.

2.3 A Survey of 3D Object Detection Algorithms for Intelligent Vehicles Development

This survey highlights the importance of 3D object detection in intelligent driving technology, particularly for the development of safe and reliable self-driving cars.

Background:

- Despite the significant advancements in 2D object detection, particularly in computer vision applications, there are limitations when it comes to intelligent driving.
- The safety and reliability of self-driving cars require the ability to detect 3D models of objects in their surroundings to perceive real driving situations accurately.

Development of 3D Object Detection:

- The paper systematically surveys the development of 3D object detection methods applied to intelligent driving technology.
- It analyzes the shortcomings of existing 3D detection algorithms and discusses future development directions in this field, emphasizing the importance of accurate environment perception for reducing traffic accidents.

Hardware Preparations for Intelligent Driving:

- The paper discusses the technologies demanded by intelligent driving, including sensors, high-precision maps, Internet of Vehicles (IoV), and high-performance chips.
- It provides an overview of the development levels of autonomous driving, highlighting the progression from Level 0 (fully manual) to Level 5 (fully autonomous).

3 YouTube Videos Regarding 3D Mapping Technologies

3.1 3D Time-of-Flight (ToF) camera for accurate 3D depth imaging — e-con Systems

- **Link:** https://www.youtube.com/watch?v=8JIBTZCXkHw
- **Description:** DepthVista is a 3D Time-of-Flight (ToF) camera designed by e-con Systems for accurate 3D depth imaging to help Autonomous Mobile Robots (AMRs) and Automated Guided Vehicles (AGVs) with safer navigation.
- **Features:**
  - Streams 3D depth data & RGB data in single frame: Enables both obstacle detection & object recognition/identification with one camera.
  - Uses VCSEL of 850nm: Safer for human eyes and can operate even in absolute darkness.
  - High speed & high resolution 640×480 @ 30 fps: Allows AMRs and AGVs to perceive their environment and plan their paths optimally, and safely complete their tasks.
  - Onboard depth image processing: Provides ready-to-use depth data from the camera itself thereby reducing the computational load on the host.
- **Target Applications:**
  - Autonomous Mobile Robots (AMRs)
  - Autonomous Guided Vehicles (AGVs)
  - People counting in retail analytics
  - Patient care / Patient Monitoring
  - 3D Face recognition for anti-spoofing
  - Robotic arms

3.2 Distance linear image sensor / Object detection [TOF]

- **Link:** `https://www.youtube.com/watch?v=YOP-fXSTbzQ`
- **Description:** The distance image sensors are designed to measure the distance to an object using the TOF method. This video demonstrates distance measurement to a target object ahead (human) using a unit equipped with a distance linear image sensor and light source. The output waveform, matched to the target object's position and movement, is shown.

3.3 Visionary-T Mini: 3D ToF camera solving industrial applications

- **Link:** https://www.youtube.com/watch?v=n6u2HQ5R2w8
- **Description:** The Visionary-T Mini ensures more efficiency in industrial settings wherever reliable 3D depth values for dynamic processes are needed.
- **Fields of Applications:**
  - Object detection
  - Navigation
  - Palletizing and depalletizing
  - Measurement and volume detection
  - Positioning
  - Gesture control
  - Area monitoring

4 Project Plan

1. **Planning and Research:**
   - Define objectives and requirements.
   - Research components and potential challenges.
2. **Component Procurement:**
   - Purchase necessary components.
   - Ensure compatibility and quality.
3. **Sensor Calibration:**
   - Develop calibration algorithms.
   - Test and refine calibration process.
4. **Hardware Development:**
   - Assemble hardware components.
   - Optimize layout and connections.
   - Conduct preliminary testing.
5. **Power Optimization:**
   - Implement power-saving techniques.
   - Validate efficiency through testing.
6. **Software Development:**
   - Develop software utility for real-time monitoring and object detection.
   - Design user-friendly interface.
   - Integrate with hardware.
7. **Testing and Validation:**
   - Conduct thorough testing.
   - Validate accuracy and reliability.
   - Test object tracking capabilities.
8. **Documentation and Finalization:**
   - Document project details.
   - Address any remaining issues.
9. **Presentation and Deployment:**
   - Present project outcomes.
   - Gather feedback.
   - Plan for deployment or further development.

5 Stakeholder Map

- The stakeholder map diagram delineates various stakeholders involved in a project, categorized based on their levels of interest and influence. Through a quadrant-based approach, stakeholders are strategically positioned according to their degree of engagement and impact on project outcomes.
- This systematic classification facilitates stakeholder management by enabling the anticipation of stakeholders' needs, ensuring thorough engagement with key stakeholders, and maintaining regular communication channels with those deemed most critical.
- By aligning stakeholder engagement strategies with their respective levels of interest and influence, project stakeholders can be effectively managed to optimize project outcomes.

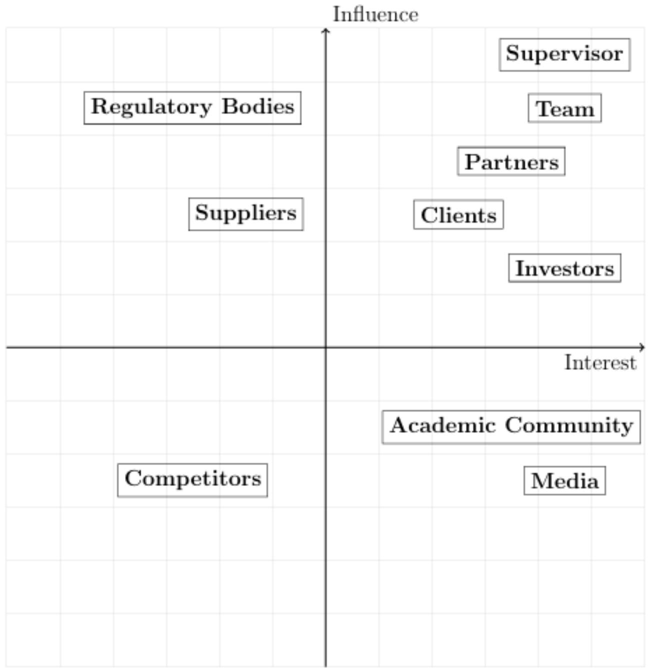

Figure 4: Stakeholder Map

6 Conclusion

In conclusion, the "3D Mapping Device Project" has made significant strides in applying engineering principles, mathematics, science, and hands-on skills to develop a sophisticated and versatile scanning system. Over the course of its development, the project team has demonstrated a deep understanding of various engineering concepts and methodologies, ensuring that the device meets industry standards while also addressing broader societal needs.

Ultimately, the stakeholder map highlights the importance of engaging and managing various stakeholders, including supervisors, team members, investors, clients, partners, regulatory bodies, suppliers, competitors, media, academic community, and users. The project could greatly improve efficiency, accuracy, and cost-effectiveness across different industries, making it an exciting and promising initiative.