WHITEPAPER

Applying Computer Vision for **Workers' Safety in the Construction Industry**

Introduction

Site safety is paramount to all construction-related activities, and encompasses many different risks like working around moving machinery or at a height, using power tools, etc. Among these risks working around cranes and suspended loads is very common. A suspended load is any object that is lifted above the ground. The larger and heavier the load, the more hazardous its surrounding areas become. The U.S. Bureau of Labor Statistics reports that there are more than 50,000 "struck by falling object" recordable injuries every year in the United States. That's one injury every 10 minutes caused by a dropped object in the workplace. This potential risk must be mitigated, and the best way to reduce the risk is monitor and ensure that all safety policies related to the suspended load are followed by workers on site. Given that construction companies are always looking for better options, computer vision techniques provide more efficient, around the clock monitoring.

In this whitepaper, we will discuss the computer vision techniques implemented to monitor a suspended load at a construction site, addressing the aforementioned risk.

Problem Definition

A suspended load is considered a hazard because an unexpected fall can be lethal. A suspended load that falls can quickly break and split, becoming a series of injurious and deadly projectiles. Harmful splashes, flooding, shattered bones, and injuries to the eyes, head, and soft tissues can occur.

Suspended loads also pose a risk because they swing and rotate given the smallest force from a worker's hand. Therefore, hands-free lifting is encouraged. Hands-free lifting is when a person doest not touch a suspended weight (with any part of their body) that is attached to a mechanical lifting mechanism. The goal of hands-free lifting is to prevent any caught between, struck-by, and struck-against events by removing the energy source from the hands and fingers of the workers. When the load's rotation or swinging is or may become hazardous, or if the load requires guidance, tag lines or safety restraint lines must be utilized. (A tag line is a piece of rope attached to the load.)

One of our clients, a leader in the construction industry, wants LTIMindtree to apply and integrate computer vision techniques with their pre-existing CCTV infrastructure to detect workers working in proximity to the load and not following the hands-free lifting approach. In turn, the detected non-compliance (with respect to safety) will be alerted to the safety officials on site through SMS and email.

Additionally, the non-compliances are to be visualized on a web application dedicated to show the computer vision model's predictions on the images being analyzed and dashboards summarizing the non-compliances with respect to time, camera, and zone. The on-site safety team can utilize the dashboards to better understand what is happening on-site. For example, what times, cameras, and zones have captured more non-compliances than others and require more focus.

Scope

The scope of work is as follows:

- Ingest images from the client's cloud cameras
- Analyze images to arrive at a feasible computer vision approach (Training)
- Apply the computer vision approach on images and predict (Live)
- Create a web-based application and give access to the customer through a secured URL
- Develop and host the necessary dashboards for visualization
- Sending SMS and emails to alert customers

System Architecture

Figure 1 represents the system architecture while Table 1 summarizes each component present.

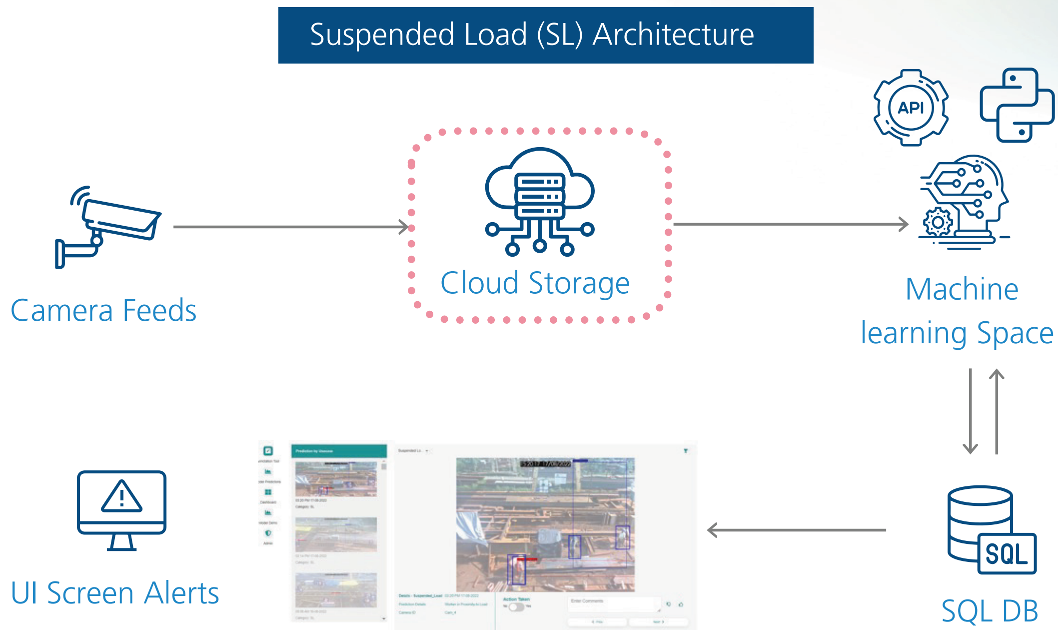


Figure 1: System Architecture

Components	Description
Camera Feeds	The images are retrieved from the cloud cameras.
Cloud Storage	The virtual machine gives the solution a platform to host necessary micro-services.
App Service	The images are stored in the cloud.
Machine Learning Space	The python computer vision model is hosted in the machine learning space and predicts images from the cloud.
SQL Database	The database holds all the data generated by the application.
User Interface	The end user interacts with the underlying application through the user interface.

Table 1: Brief description of components

Technology Stack

Technology	Version	Usage
Python	3.6.2	Used to predict computer vision models on images.
Azure-ML	1.39.0	Used to deploy the computer vision models to the machine learning space.
MS SQL Server	2019	Stores data from the application.
Angular	8.3.26	Used to develop the user interface.
NodeJS	8.5.5	Used to develop the user interface.
.Net Core	3.1	Used to develop the user and API interface.

Table 2: Technology Stack

Solution Approach

By integrating computer vision techniques and pre-existing CCTV infrastructure, the risk posed by workers in proximity to a suspended load can be monitored and safety officials can be alerted to this non-compliance. As shown below in the flowchart, three different computer vision object detection models work in tandem to monitor suspended load movements. The following depicts the same and the training pipeline.

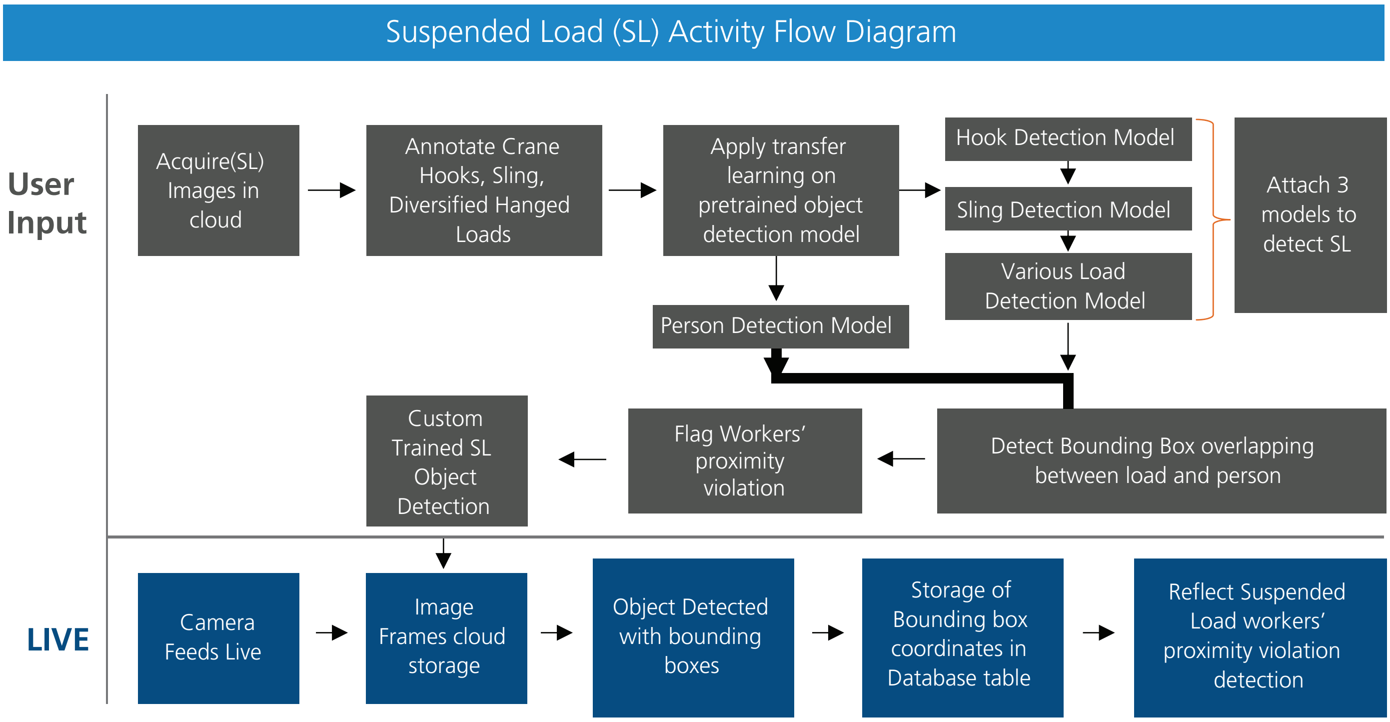
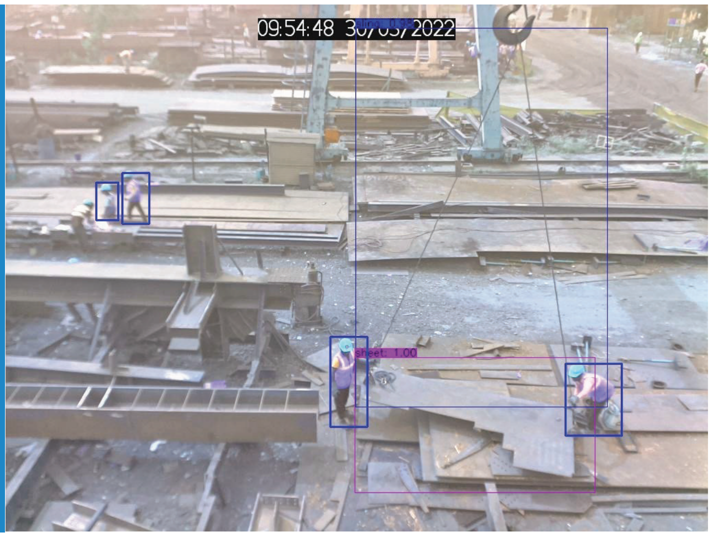


Figure 2: Outline of Suspended Load Computer Vision Training Pipeline and Workflow

First, the presence of a suspended load scenario is confirmed by detecting the hook block and sling of the crane. Further, if a suspended load scenario is occurring, then the load is detected. The load can be of different shapes and sizes and hence, the model must be trained for different types of suspended weights. The detected load is checked along with the detected hook and sling to see if the two bounding boxes intersect – confirming the location and presence of a suspended load. Upon this confirmation, a person detection model is used to locate the workers in the image. If a detected worker's bounding box intersects with that of the load's, it can be understood that the worker is in proximity (an example is shown below in Figure 3). If a worker is in proximity to the load, the site's safety officials are alerted by SMS and email, and it is also reflected in the web application and dashboards. The solution was developed using LTIMindtree platform.

Figure 3: Computer Vision Model Prediction of Worker in Proximity to Suspended Load



Business Benefits

This computer vision solution aims at helping the client monitor safety at their construction sites with respect to suspended loads.

The beneficial aspects of the solution can be listed as below:

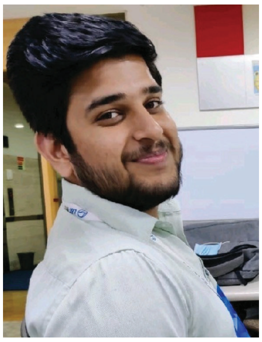
- User-friendly application to view non-compliance image predictions and raise tickets to initiate the right course of action.
- Efficient, automated, round-the-clock monitoring capabilities can replace monitoring manpower required.
- It is deployed in the cloud with 24x7 uptime.
- Highly intuitive dashboards that publish summarized views of the suspended load non-compliances at construction sites.
- Helps the client create awareness regarding safety protocols being used at a construction site.
- Customizable and scalable to handle more cameras and sites at any time.

Using computer vision to monitor safety can help in reducing risk at construction sites and help increase awareness among the construction workers to follow safety policies. This may subsequently improve safety on site and reduce accidental cases related to suspended loads.

Conclusion

This white paper demonstrates the need for using computer vision to monitor worker safety at construction sites with respect to suspended loads. Subsequently, it minimizes risk and increases awareness in all fronts. Therefore, a service which can provide monitoring solutions can be beneficial for the construction industry.

About the Authors



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