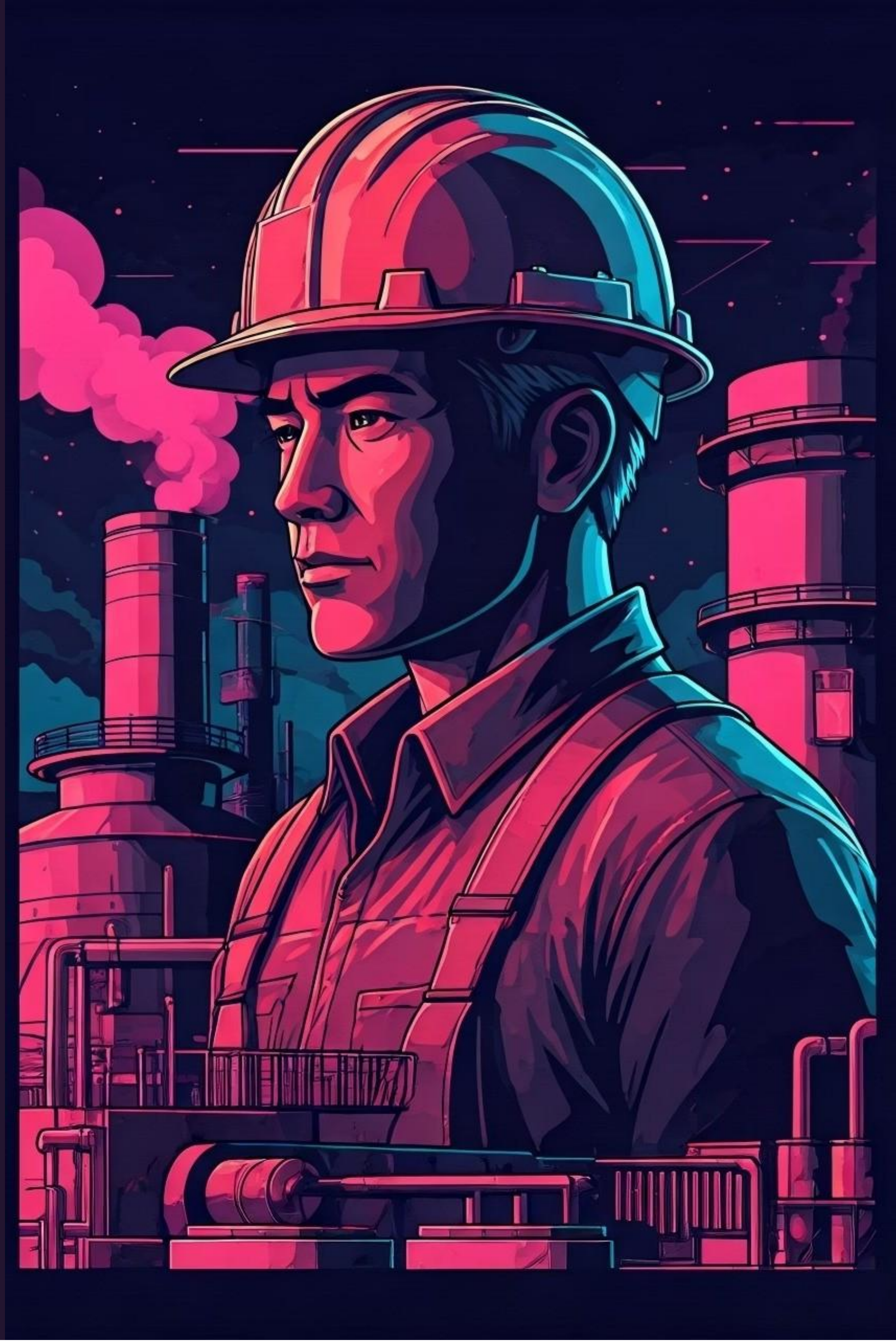
Safety Helmet Detection: A Technical Deep Dive

This presentation outlines the process, methodology, and preparation of data for building an automated safety monitoring system in construction and industrial environments.



Project Introduction & Goal

Crucial Task: Detection

Focuses on automating the detection of safety helmets in various industrial and construction images.

Preventing Head Injuries

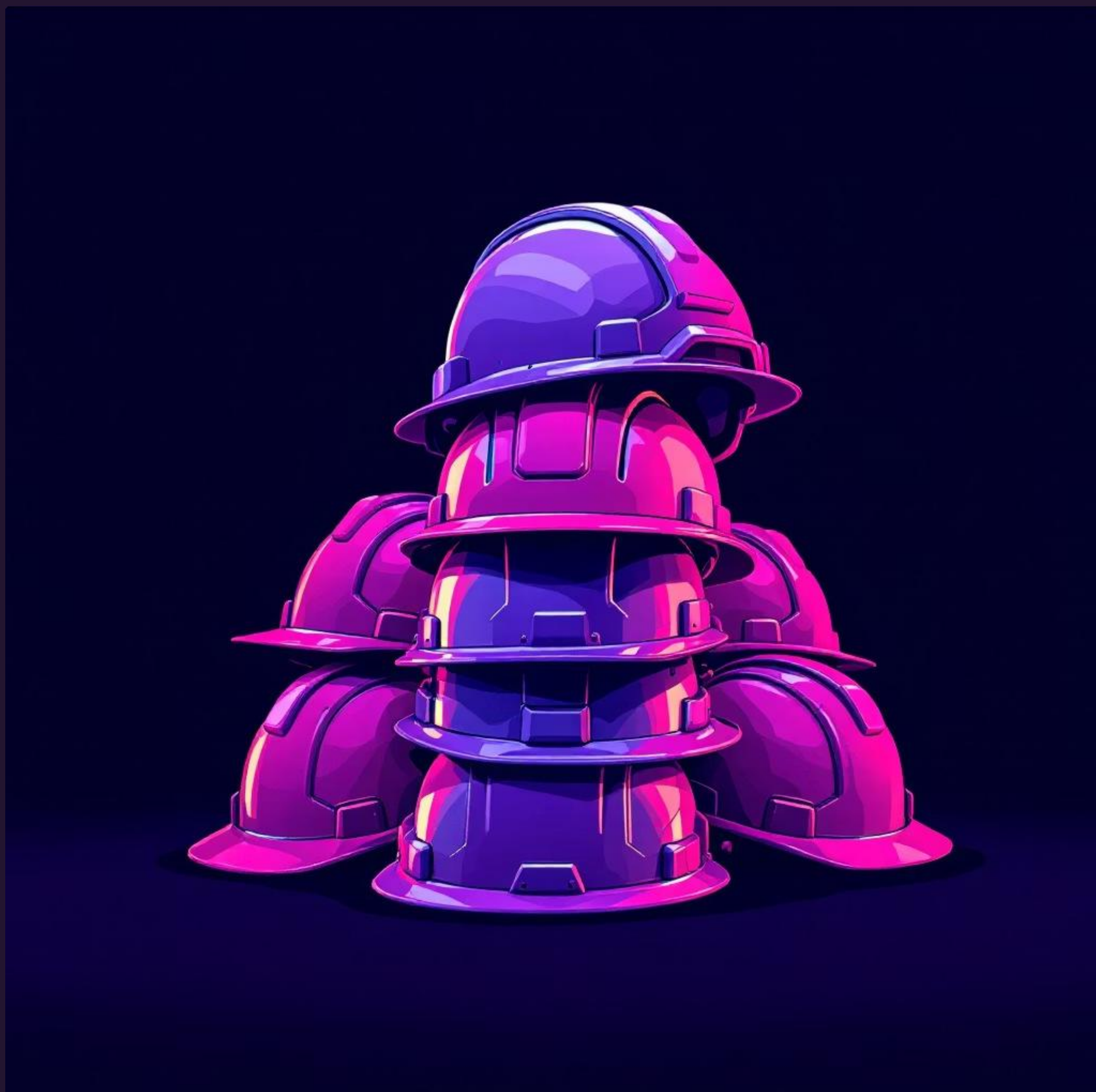
Ensuring compliance with safety regulations is vital to prevent severe head trauma among workers.

Automated Monitoring

The project delivers the foundational data preparation steps for an effective automated safety monitoring system.

Dataset Overview: Hard Hat Detection

The project utilises the publicly available "Hard Hat Detection" dataset from Kaggle, providing diverse images and precise annotations necessary for object detection training.



Source

Kaggle: Hard Hat Detection Dataset (downloaded using `kagglehub` library).

Content

Images from diverse real-world environments where hard hats are mandated.

Annotation Format

Pascal VOC XML format, detailing bounding box coordinates and object labels.

Target Object Classes

The detection model is trained to identify three distinct classes, allowing for granular monitoring of safety compliance (helmet worn) versus non-compliance (head visible without helmet).

Helmet

Identifies workers correctly wearing their mandated safety headgear.

Head

Identifies the head of a worker, typically indicating non-compliance (missing helmet).

Person

Identifies the general location of a worker within the frame for context and tracking.

Chapter 2

Methodology: Data Preparation Pipeline

The structured methodology ensures high-quality, standardized data suitable for modern object detection frameworks.

Data Loading

Downloading raw data and initial parsing of the Pascal VOC XML annotation files.

Annotation Parsing

Extracting bounding boxes (xmin, ymin, xmax, ymax) and labels into a structured Pandas DataFrame.

Exploratory Data Analysis (EDA)

Analyzing distribution, density, and physical characteristics of objects.

YOLO Conversion

Converting normalized coordinates into the YOLO text file format for model training.

Exploratory Data Analysis (EDA) Insights

EDA provides critical insights into class balance, object density, and size distribution, informing model selection and training strategies.

Label Distribution

Analysis of class frequencies (helmet, head, person) to check for potential class imbalance issues.

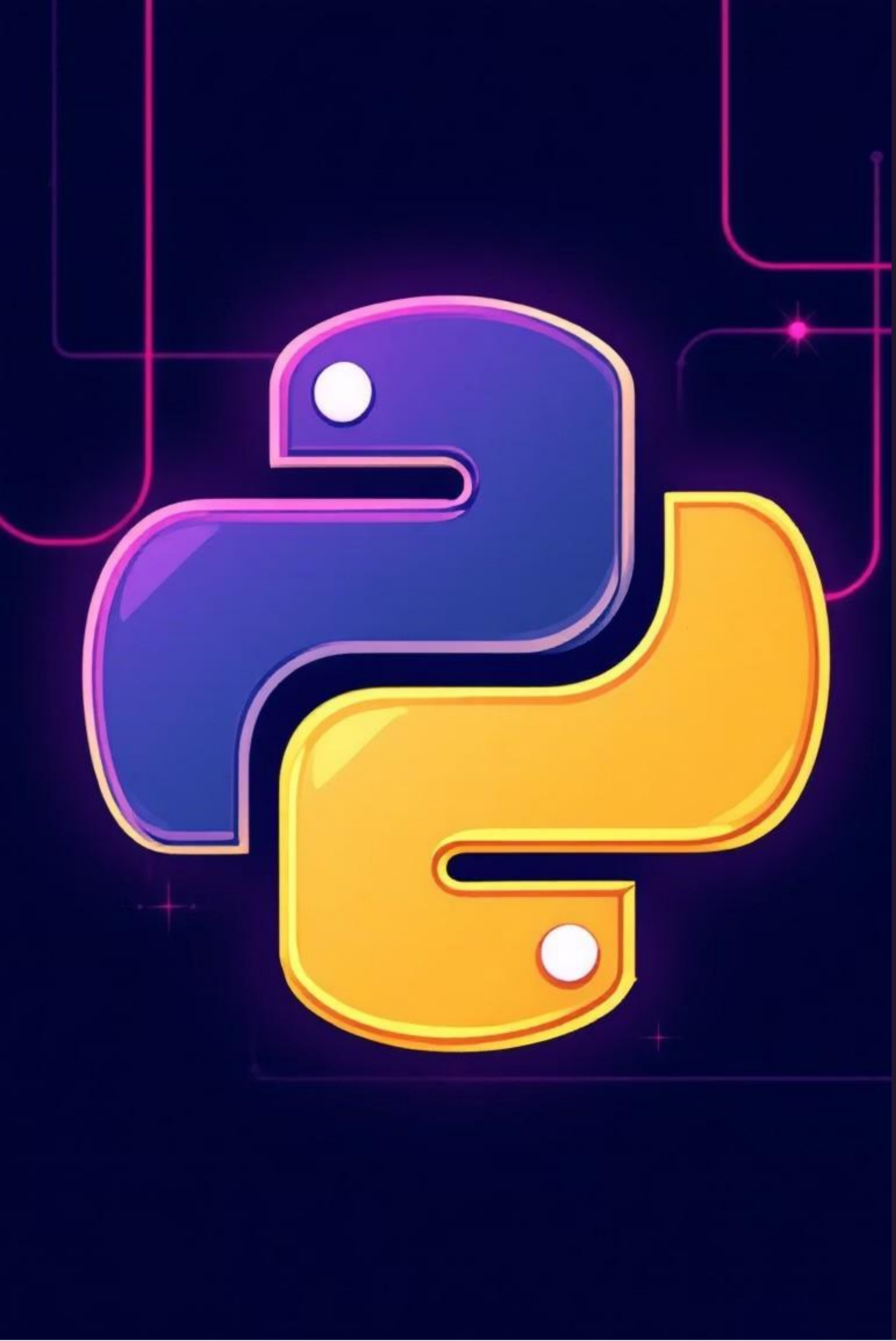
Objects per Image

Visualising object density to understand if the model needs to handle high-density scenarios.

Bounding Box Analysis

Studying the area and center coordinates to understand object scale and spatial placement.

This process utilizes `matplotlib` and `seaborn` for generating informative plots such as count plots, histograms, box plots, and heatmaps.



Code Implementation and Libraries

The entire data pipeline is implemented within a Jupyter Notebook, leveraging standard data science and computer vision libraries.

Core Libraries

- `pandas` for data structuring and manipulation.
- `opencv-python` for image operations (if needed).
- `matplotlib` and `seaborn` for visualization.

Key Functions

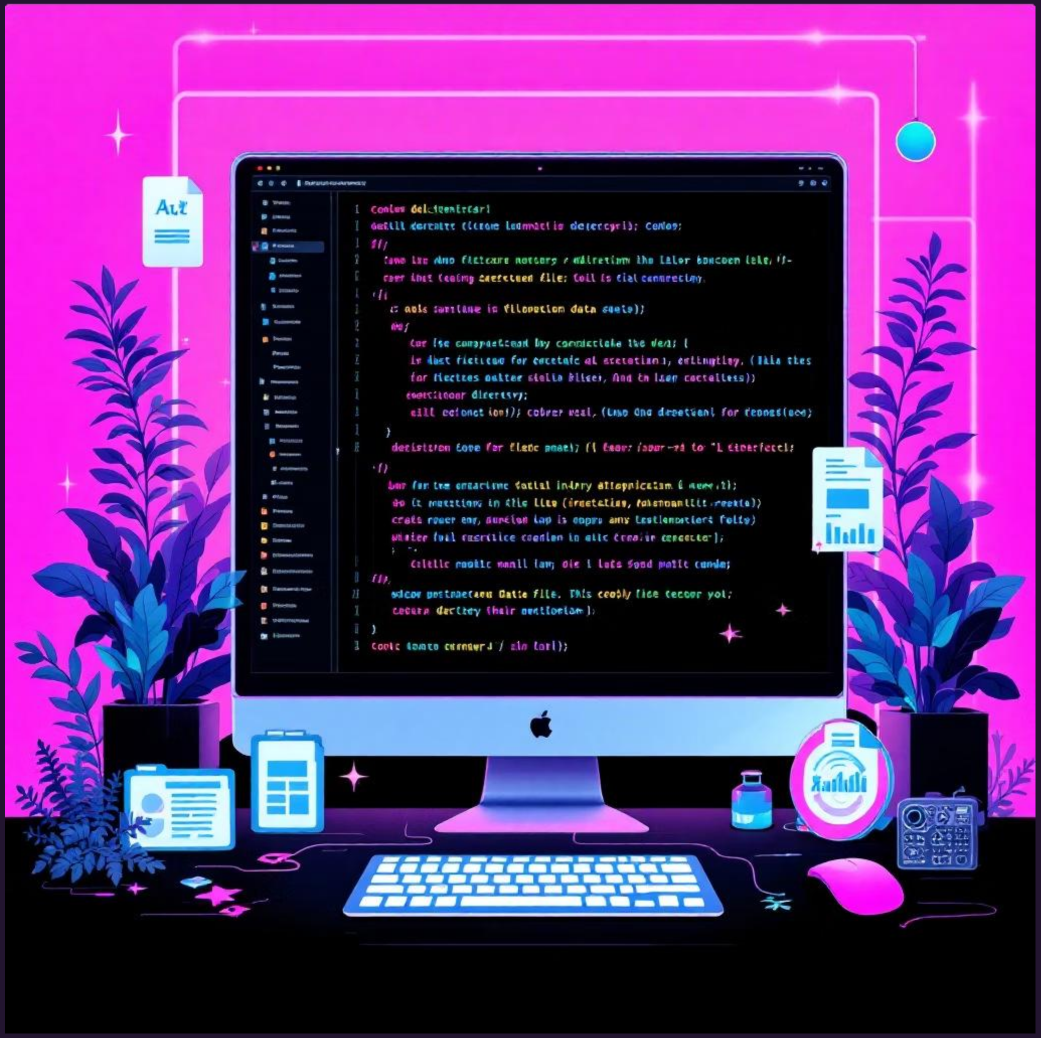
- `parse_voc_annotation:` Reads and structures XML data.
- `voc_to_yolo`: Handles the critical coordinate normalization and conversion process.

Chapter 3

Key Project Results

The data preparation yields several essential outputs, ready for immediate model consumption.

- **annotations.csv:** A comprehensive CSV file compiling all parsed bounding box data (path, label, coordinates) from the dataset.
- **YOLO Dataset Structure:** A new directory (`yolo_dataset`) containing images and corresponding YOLO-format label files.
- **Visualizations:** EDA charts providing quantitative and visual validation of the data characteristics.



Data Distribution: Key Visual Insights

Analysis confirms the dataset9s characteristics concerning class balance and object size, vital for efficient model training.

60%

Helmet Frequency

The 'helmet' class is confirmed as the most frequent label, which is positive for training detection focus.

30%

Person Bounding Area

Bounding boxes for 'person' are significantly larger than those for 'head' or 'helmet'.

80%

Central Concentration

Objects are most often located in the central regions of the images, suggesting a focus on main subjects.

This informs us that while the 'helmet' class is abundant, the model must be robust in detecting small objects ('head'/'helmet') within large bounding boxes ('person').

Conclusion: Ready for Training

This project successfully completed the complex process of data ingestion, normalization, and preparation, resulting in a ready-to-use dataset.

Data Processing Success

Processed the raw dataset into a clean, structured, and verified format.

YOLO Format Output

Generated a fully prepared YOLO dataset, optimized for modern detection models.

Key Insights Gained

EDA provided valuable knowledge on class distribution and object density.

Direct Integration

The output is ready to be used directly to train models like YOLOv8 for automated safety monitoring.