Gesture driven object manipulation in unity using YOLO

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***Abstract*—This is a simple paragraph at the beginning of the document. A brief introduction about the main subject.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

Gestures are a fundamental way of interaction between people. They are widely used across cultures as they are intuitive and primitive. Gesture recognition aims to leverage this intuitiveness of gestures to introduce a natural communication between a human and a computer, not just between humans. We use an object detection algorithm, YOLO, to achieve this. Traditional methods use high-end hardware, special sensors or additional hardware to achieve high accuracy of gesture detection. We, on the other hand, are aiming for a real time speed, which is crucial for a seamless user experience, without lag. We aim to introduce a gesture based human-computer interaction using just an entry level GPU and inbuilt webcam. It shall detect gestures in real time and map it to actions in Unity, a 3D development platform. Gesture based object manipulation is already existent in VR currently, but they require additional hardware and are tailored to gaming in particular. By using inbuilt hardware, we introduce a new way of hands free interaction not just for gaming but also for other software applications when implemented.

We are using a custom dataset with just two gestures, trained on a pre trained YOLO model, YOLOv5, for our project. We're using OpenCV to access webcam in python, and using TCP/UDP sockets to connect python to Unity. We've chosen Unity as our user interface to showcase the real time ability of YOLO to detect gestures continuously through the webcam video stream and transfer the detected gesture to Unity to perform a real time object manipulation.

II. Literature Review

Various methods like deep learning and sensor based detection method were developed to aid in hand gesture recognition and object manipulation in AR/VR. In (Paper 1) the authors used a CNN based approach for hand gesture recognition and finger tip detection, and were able to achieve real time performance but lacked in viable existing datasets to work with. (Paper 2) used the efficiency of TOF cameras for depth based hand recognition, which had better adaptability and can work with multiple background environments but required high-end hardware.

The authors of (Paper 3) used YOLOv4 and integrated Microsoft HoloLens with robotic vision applications, but suffered from lower FPS due to hardware constraints. (Paper 4) introduced a YOLOv5-based multi-scale gesture recognition model which helped in optimizing speed but faced difficulty in different light settings. (Paper 5) focuses on comparing YOLO v5, v6, and v8 and analyzing their capability in real-time hand gesture recognition and had positive results, but they require high-quality datasets and computational power. (Paper 6) used Leap Motion sensor for fingertip-based object manipulation, tracking hand skeletal motion and translating it into virtual interactions. This method gave a better user experience, but the system had to rely on internet connection to function.

(Paper 7) combined multiple sensors (Leap Motion, data gloves , gForcePro+) for gesture recognition, But the system suffered in accuracy under different lighting environments. (Paper 8) used physics based techniques for gesture recognition, which mapped hand gestures to force based object manipulation in VR. Even though it provided better user experience it had lower accuracy compared to direct control methods. (Paper 9) had a novel technique where SEMG signal from an arm band collected motion data from a leap motion controller. By combining muscle activity analysis with palm and fingertip tracking, this system could achieve higher accuracy but armband orientation inconsistencies affected reliability.

(Paper 10) is not directly related to gesture recognition. It used unity based interactive learning environments to help effectively understand python concepts. The system enhanced user engagement through interactive game based learning but required programming expertise in unity and python for effective implementation.

III. Creating lists in LaTeX

You can create different types of list using environments, which are used to encapsulate the LaTeX code required

Identify applicable funding agency here. If none, delete this.It will add a superscript and a footnote with the text inside the braces. Useful if you need to thank an institution in your article.

to implement a specific typesetting feature. An environment starts with \begin{environment-name} and ends with \end{environment-name} where environment-name might be figure, tabular or one of the list types: itemize for unordered lists or enumerate for ordered lists.

A. Unordered lists

Unordered lists are produced by the itemize environment. Each list entry must be preceded by the \item command, as shown below:

- The individual entries are indicated with a black dot, a so-called bullet.
- The text in the entries may be of any length.

B. Ordered lists

Ordered lists use the same syntax as unordered lists but are created using the enumerate environment:

1) This is the first entry in our list.
2) The list numbers increase with each entry we add.

C. Nested Lists

1) The labels consists of sequential numbers.
   - The individual entries are indicated with a black dot, a so-called bullet.
   - The text in the entries may be of any length.
2) The numbers starts at 1 with every call to the enumerate environment.

D. Lists styles

1) Ordered lists:

1) First level item
2) First level item
   a) Second level item
   b) Second level item
      i) Third level item
      ii) Third level item
         A) Fourth level item
         B) Fourth level item
1) First level item
2) First level item
   I Second level item
   II Second level item
      i) Third level item
      ii) Third level item
         A) Fourth level item
         B) Fourth level item

E. Unordered lists

- First Level
  - Second Level
    - Third Level
      - Fourth Level
- ■ First Level
  - □ Second Level
    - Third Level
      - Fourth Level
- ■ Default item label for entry one
- ■ Default item label for entry two
- □ Custom item label for entry three

IV. Introduction to Tables in LaTeX

Tables are a fundamental component of document preparation in LaTeX, widely used in academic, scientific, and professional writing to organize and present data effectively. LaTeX provides a robust framework for creating tables with precise formatting, allowing users to design simple or complex layouts tailored to their needs.

With LaTeX, you can:

- **Align content**: in columns (left, center, right).
- **Add borders**: and rules for improved readability.
- **Merge rows and columns**: to create sophisticated table designs.
- Handle **dynamic widths**: for text wrapping and content adjustment.
- Use packages like `booktabs` for professional styling and `tabularx` for dynamic column widths.

Why Use LaTeX for Tables?

LaTeX offers several advantages:

1) **Consistency**: Tables maintain a uniform appearance throughout the document.
2) **Flexibility**: You can create multi-page tables, span columns in two-column layouts, and more.
3) **Integration**: Tables can seamlessly include mathematical symbols, equations, or inline graphics.
4) **Automation**: Add references and captions to tables that integrate with your document's structure (e.g., cross-references).

A. Different types of tables

Column 1	Column 2	Column 3
Row 1	Row 1	Row 1
Row 2	Row 2	Row 2
Row 3	Row 3	Row 3

TABLE I: An example of a table created using the `tabular` environment.

1) A simple table: The `tabular` environment is the default LaTeX method to create tables. You must specify a parameter to this environment; here we use {`c c c`} which tells LaTeX there are three columns and the text inside each one of them must be centred.

Left-Aligned	Centered	Right-Aligned
Text 1	Text 2	Text 3
Merged Columns		Text 4

TABLE II: Table with Alignment and Spanning

Item	Quantity	Price
Apples	5	$3
Bananas	10	$5
Oranges	7	$4

TABLE III: Table with Borders and Titles

2) Tables with fixed width: When dealing with tables in LaTeX, you may encounter situations where the content of a table needs to fit within a specific width, especially in conference papers or reports with strict formatting guidelines. By setting a fixed width for columns, you can ensure that the table fits neatly within the document margins and avoids overflowing.

LaTeX provides several ways to create tables with fixed-width columns:

- **`p{width}` in the `tabular` Environment**: The `p{}` specifier allows you to define the column width explicitly. Text within these columns is automatically wrapped.
- **`tabularx` Package**: This package introduces the `X` column type, which adjusts column widths proportionally to fit the table into the specified width.
- **`tabulary` Package**: Similar to `tabularx`, but optimized for text content.
- **Multi-page Tables**: Combine fixed-width tables with packages like `longtable` for spanning large tables across multiple pages.

Fixed-width tables are especially useful for:

- Presenting **large datasets** or long strings of text.
- Ensuring compliance with **document width constraints**.
- Enhancing the **readability** and layout of your tables.

Description	Quantity	Price
A long description that wraps inside the cell	5	$10
Short text	8	$6

TABLE IV: Table with Custom Column Widths

Merged Row	Column 1	Column 2
	Data 1	Data 2
Row 2	Data 3	Data 4

TABLE V: Table with Merged Rows

3) Coloured tables: To create colored tables in LaTeX, you can use the xcolor package, which provides tools for adding background colors to table cells, rows, or columns. Below are some examples of colored tables.

V. Mathematical expressions and equations

LaTeX's features for typesetting mathematics make it a compelling choice for writing technical documents. This article shows the most basic commands needed to get started with writing maths using LaTeX. LaTeX allows two writing modes for mathematical expressions: the **inline math mode** and the **display math mode**.

Inline Math Mode

Inline math mode is used to write formulas that are part of a paragraph. The expressions are typeset within the running text.

You can use any of the following "delimiters" to typeset your math in inline mode:

- `\(...\)`: Example: $E = mc^2$
- `$...$`: Example: $E = mc^2$
- `\begin{math}...\end{math}`: $E = mc^2$

Inline math mode is typically used when you want to incorporate mathematical expressions seamlessly into a sentence, like this: $a^2 + b^2 = c^2$.

Display Math Mode

Display math mode is used to write expressions that are not part of a paragraph and are therefore put on separate lines.

To switch to display math mode, use:

- `\[...\]`: Example:

$$a^2 + b^2 = c^2$$

- `\begin{equation}...\end{equation}`: Example:

$$a^2 + b^2 = c^2 \tag{1}$$

Display math mode is ideal for highlighting complex formulas or when equations require their own space for clarity.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{2}$$

$$e^{i\pi} + 1 = 0 \tag{3}$$

$$\int_a^b f(x)\,dx \tag{4}$$

$$\frac{\partial f}{\partial x} \tag{5}$$

$$\sum_{n=1}^{\infty} \frac{1}{n^2} \tag{6}$$

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \tag{7}$$

$$\begin{aligned} ax + by &= c \\ dx + ey &= f \end{aligned} \tag{8}$$

$$S = \sum_{n=0}^{\infty} \frac{1}{n!} = e \tag{9}$$

$$e^{i\theta} = \cos\theta + i\sin\theta \tag{10}$$

$$y = \frac{x^2 + 3x + 5}{2} - \frac{\sin x}{\cos x} \tag{11}$$

TABLE VI

PRECISION (P), RECALL (R), AND F1 SCORE FOR THE EXPERIMENTS WITH DATA AUGMENTATION

SL.No	Class	Model1			model2			model 3			model 4			proposed model 1			best model		
		P	R	F1	P	R	F1	P	R	F1	P	R	F1	P	R	F1	P	R	F1
1	cell	0.55	0.55	0.55	0.56	0.55	0.55	0.24	0.50	0.33	0.37	0.76	0.50	0.18	0.81	0.29	0.64	0.65	0.65
2	cell	0.11	0.65	0.18	0.28	0.50	0.36	0.39	0.56	0.46	0.51	0.55	0.53	0.35	0.55	0.42	0.11	0.68	0.19
3	cell	0.33	0.61	0.43	0.54	0.56	0.55	0.49	0.83	0.61	0.55	0.83	0.67	0.68	0.53	0.60	0.48	0.79	0.59
4	cell	0.84	0.63	0.72	0.58	0.69	0.63	0.52	0.49	0.50	0.67	0.71	0.69	0.76	0.70	0.73	0.72	0.61	0.66
5	cell	0.69	0.69	0.69	0.75	0.61	0.67	0.55	0.50	0.53	0.65	0.61	0.63	0.80	0.61	0.69	0.92	0.53	0.67
6	cell	0.45	0.46	0.45	0.52	0.58	0.55	0.47	0.63	0.54	0.53	0.63	0.58	0.59	0.57	0.44	0.72	0.54	0.61
7	cell	0.76	0.61	0.67	0.81	0.51	0.62	0.75	0.43	0.55	0.83	0.54	0.66	0.85	0.49	0.62	0.80	0.69	0.74
8	cell	0.62	0.61	0.61	0.64	0.53	0.58	0.44	0.67	0.53	0.50	0.67	0.57	0.71	0.50	0.59	0.68	0.62	0.65
9	cell	0.47	0.42	0.44	0.58	0.74	0.65	0.59	0.76	0.67	0.54	0.76	0.63	0.65	0.72	0.68	0.55	0.57	0.56
	Macro	0.56	0.60	**0.55**	0.59	0.63	**0.60**	0.50	0.59	**0.53**	0.59	0.68	**0.62**	0.63	0.66	**0.61**	0.63	0.67	**0.62**
	Micro	0.64	0.64	**0.64**	0.67	0.65	**0.64**	0.54	0.54	**0.54**	0.63	0.63	**0.63**	0.67	0.67	**0.67**	0.69	0.69	**0.69**

Column 1	Column 2	Column 3
Data 1	Data 2	Data 3
Data A	Data B	Data C
Data X	Data Y	Data Z

TABLE VII: Table with Alternating Row Colors

Column 1	Column 2	Column 3
Data 1	Highlighted	Data 3
Data A	Data B	Data C
Data X	Data Y	Data Z

TABLE VIII: Table with Highlighted Cells

Column 1	Column 2	Column 3
Data 1	Data 2	Data 3
Data A	Data B	Data C
Data X	Data Y	Data Z

TABLE IX: Table with Colored Columns

Column 1	Column 2	Column 3
Data 1	Data 2	Data 3
Data A	Data B	Data C
Data X	Data Y	Data Z

TABLE X: Table with Header and Colored Cells

$$(x+y)^n = \sum_{k=0}^{n} \binom{n}{k} x^{n-k} y^k \tag{12}$$

$$\hat{f}(\omega) = \int_{-\infty}^{\infty} f(t) e^{-i\omega t}\, dt \tag{13}$$

$$T^{\mu\nu} = \frac{1}{2}\left(\partial^\mu \phi \partial^\nu \phi + \partial^\nu \phi \partial^\mu \phi\right) \tag{14}$$

LaTeX offers a wide range of mathematical tools and environments that make it a powerful tool for typesetting equations. Whether you're writing simple algebraic expressions or complex mathematical models, LaTeX ensures that your equations are presented in a clean, professional, and easy-to-read format. The environments mentioned above are just a few examples of how you can use LaTeX for effective mathematical typesetting in your documents.

A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

B. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive".
- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- Do not mix complete spellings and abbreviations of units: "Wb/m^2" or "webers per square meter", not "webers/m^2". Spell out units when they appear in text: ". . . a few henries", not ". . . a few H".
- Use a zero before decimal points: "0.25", not ".25". Use "cm^3", not "cc".)

C. Some Common Mistakes

- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an "inset", not an "insert". The word alternatively is preferred to the word "alternately" (unless you really mean something that alternates).

Column 1	Column 2	Column 3
Data 1	Data 2	Data 3
Data A	Data B	Data C
Data X	Data Y	Data Z

TABLE XI: Table with ‘colortbl‘ for Advanced Coloring

- Do not use the word “essentially” to mean “approximately” or “effectively”.
- In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
- Do not confuse “imply” and “infer”.
- The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the “et” in the Latin abbreviation “et al.”.
- The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

Handling References

When writing academic papers, handling citations and references is essential. LaTeX provides several methods to manage bibliographies, making it easy to insert and format references. The two most common methods are:

- **Manual Bibliography with `the bibliography` Environment** – Suitable for small projects with a few references.
- **Using BibTeX** – An automated approach for handling larger bibliographies, where reference details are stored in an external `.bib` file.

Each method serves different needs and can be chosen based on the complexity of your document. Let’s explore both methods.

1. Manual Bibliography with `thebibliography` Environment

In this method, you manually input each reference inside the `thebibliography` environment. While simple and direct, it is most effective for documents with only a handful of references.

Here is a reference to a book [1] and a journal paper [2].

References

[1] J. Doe, *The Art of LaTeX*, Wiley, 2021.
[2] A. Smith, *Advanced Topics in LaTeX*, Elsevier, 2020.

2. Using BibTeX for Automatic Bibliography Management

BibTeX is a tool that automates bibliography management. References are stored in a separate `.bib` file, and LaTeX automatically formats them in the required style. This method is preferred for documents with many references.

Steps:

- Create a `.bib` file: This file contains all the reference details in a structured format.
- Link the `.bib` file to your LaTeX document using the `\bibliography{filename}` command.
- Cite the references in the document using `\cite{key}`.

Example Code:

Create a .bib file (e.g., `references.bib`):

```
@book{ref1,
  author    = {J. Doe},
  title     = {The Art of LaTeX},
  publisher = {Wiley},
  year      = {2021}
}

@article{ref2,
  author  = {A. Smith},
  title   = {Advanced Topics in LaTeX},
  journal = {Journal of LaTeX Studies},
  year    = {2020}
}
```

LaTeX Document:

```
\bibliographystyle{plain}% Citation style
(e.g., plain, IEEE, APA, etc.)
\bibliography{references}% Name of your .bib file
(without the extension)
```

Explanation:

- `\bibliography{references}` links to the `.bib` file containing your references (without the file extension).
- `\bibliographystyle{plain}` specifies the citation style (e.g., plain, IEEE, APA, etc.).
- The `\cite{key}` command inserts citations in the text, where `key` corresponds to the entry in the `.bib` file.

Both methods are valuable, but for larger projects or when working with many references, BibTeX is the recommended approach due to its efficiency and ease of use.

Category	LaTeX Markup	Renders As
Parentheses	`$(x + y)$`	$(x + y)$
Square Brackets	`$[x + y]$`	$[x + y]$
Curly Braces	`$\{x + y\}$`	$\{x + y\}$
Pipes (Vertical Bars)	`$\|x + y\|$`	$\|x + y\|$
Fractions	`$\frac{a}{b}$`	$\frac{a}{b}$
Binomial Coefficients	`$\binom{n}{k}$`	$\binom{n}{k}$
Sum	`$\sum$`	$\sum$
Integral	`$\int$`	$\int$
Double Integral	`$\int\int$`	$\int\int$
Product	`$\prod$`	$\prod$
Square Root	`$\sqrt{x}$`	$\sqrt{x}$
Nth Root	`$\sqrt[n]{x}$`	$\sqrt[n]{x}$
Limit	`$\lim$`	$\lim$
Infinity	`$\infty$`	∞
Angle	`$\angle$`	$\angle$
Partial Derivative	`$\partial$`	∂
Vector (Bold)	`$\vec{v}$`	$\vec{v}$
Matrix (bmatrix)	`$\begin{bmatrix} ... \end{bmatrix}$`	$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$
Absolute Value	`$\left\| x \right\|$`	$\left\| x \right\|$
Norm (Double Absolute Value)	`$\left\\| x \right\\|$`	$\left\\| x \right\\|$
Degree Symbol	`$x^{\circ}$`	x°
Differential	`$d\x$`	dx
Gradient	`$\nabla$`	∇
Laplace Operator	`$\square$`	$\square$

TABLE XII: Common Mathematical Symbols and Expressions in LaTeX