# Dive Performance Analytics: A Data-Driven Approach Using RVM and RTMPose

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***Abstract*—Estimation of human pose in sports is crucial for analyzing performance metrics, training optimization, and enhancing other critical tasks. However, in dynamic and fast-paced sports such as diving, pose estimation faces challenges related to both accuracy and speed. In this study, we utilize segmentation techniques such as RVM and Mediapipe to ensure accurate extraction of the diver from the background. Subsequently, we employ the RTMPose algorithm to extract key points from the diver's body and generate key performance indicators including total rotation angle, joint angles, maximum height at various stages, aimed at improving training efficiency. Evaluations of this pipeline on diving videos demonstrates that our approach achieves 3x improvement in FPS processing speed without compromising on accuracy while maintaining high fidelity tracking of human motion in real world dive scenarios. The idea of a pipeline for dive pose estimation can be a first step towards significantly improving real-time analytics in the sports industry with the help of AI and data driven approaches.**

## I. Introduction

In modern sports, improving peak performance is driven by advanced analytics and data-driven approaches. Among these, human pose estimation stands out, offering insights into an athlete's movements, enabling coaches and trainers to optimize their techniques. In dynamic sports like diving, where body posture and precise movements dictate success, pose estimation faces several challenges.

The accurate and real-time tracking of human during a dive is hindered by factors like rapid movements, complex rotations and the need to segment the diver from the background. Traditional methods of accessing dives rely on manual measurements or subjective judgment, which are time consuming and prone to human error and bias.

The introduction describes the problem you solved and why it is important. You start with a general problem definition and subsequently a more detailed description of the problem you faced. Then, you provide existing solutions to this problem or related problems and their solution. Make sure the reader understands the differences! You HAVE to use references in this section to provide an idea what has already been done in this research area. Mainly, you cite journal articles [1], conference proceedings [2], books [3] and web links [4]. Having defined the body of knowledge you introduce how you are going to solve the problem. You finish with a crystal clear purpose of your project or contribution to the problem. The literature review is written in simple past. The rest of the introduction is generally present tense. You can also use present tense for giving insight in what will be shown in the article. A rule of thumb are six references of other solutions or related projects, solutions and systems.

## II. Methods

This section includes everything the reader needs to understand your system and results. Things you just used only have to be mentioned and cited. For data recording, we used the mobile system developed by Kugler et al. [2]. Make sure to describe your contribution as short and precise as possible and as detailed as needed to reimplement it. You have to include a description of data, hardware, math, algorithms, system structure and evaluation methods and everything that was important to solve the defined problem. Make sure to order the methods so that the reader can follow your description. First things first! Make sure to structure the methods in a proper way. Use a dry description and try not to teach the reader.
The methods part is written in simple past, even if you created a live system that can still do things. It is only important what the system did on the data you presented. Only describe the best and final version of the system. The reader is not interested what you did wrong in developing the final system. Things that did not work don't have to be mentioned.

### A. Study-Design

A rule of thumb is that you describe one fact in each paragraph. That means, if you go to the next aspect, you start with a new paragraph. Try to maintain a logical structure throughout the paper where paragraphs build upon each other. A good way to structure the paper are subsections. You can also use enumerations to structure the paper. Use an unordered list if the items don't have a structure.

- Apple
- Peach
- Melon
- Grape

Use an ordered list if there is a hierarchical structure in the list.

Fig. 1. The caption of a figure explains the complete figure. The reader must be able to completely understand what he/she sees with the information in the caption. Do not expect the reader to read the text before trying to understand the figure.

1) Erlangen
2) Bavaria
3) Germany
4) Europe

You should always have more than one subsection. Otherwise the structure does not make sense.

### B. Data Collection

Add figures and cite the figures at the end of a sentence (Fig. 1). Good figures make a paper a lot better. Don't use figures if they are of bad quality or not exactly what you want to show with it. Latex puts figures where they fit best regarding the document structure. Often, figures are not at the same place as they are defined in the source code. Don't worry too much about that. Often, they are place on top of a page but the desired (not defined) positioning can be specified in the brackets after begin{figure}. Make sure the figure is readable when printed in black and white. This means that the lines in a plot have to be of different shape (dotted, dashed,...) and the coloring has to be adapted if used. Print the paper in black and white if unsure.
Add important equations that a relevant for understanding your system and cite them (Eq. 1). Every variable has to be explained. The variable $f$ denotes the force, $m$ the mass and $c$ a constant. Make sure to reference the equation or provide an explanation. When writing about value make sure to insert a safe blank between value and unit like 9.81 g or 67 % to avoid a line break between value and unit. The safe blank is also needed when referencing figures.

$$f = m \times c^2 \tag{1}$$

### C. Analysis

Make sure to use proper English in your papers. Get the paper reviewed by another person to avoid stupid typos and check the language for common mistakes. If the paper is important, try to find a native speaker for review. Some common language related problems:

- Make sure to use lower case for nouns.
- There are no strict rules for punctuation in English and, in some cases, the rules are different to German rules. One common problem is the use of a comma in a relative clause. There is no comma after "that" and "which" if it is a restrictive relative clause like "The book which I read is well written.". There is a comma if it is a non-restrictive relative clause like "That book, which incidentally I just finished reading, is well written.". A rule of thumb is that you use a comma if the relative sentence is not needed to make it a proper sentence.
- Use short sentence in paratactic form. This is easier to read. Long sentences are hard to understand. You don't write poems that are supposed to be of nice language.
- You can alternate between active and passive. Contrary to German, the use of active is also elegant. When talking about yourself you should write "the author" or "we".
- Do not abbreviate terms like "do not", "cannot" or "it is".
- Find scientific synonyms for colloquial language. You can start colloquial and then transform into scientific language afterwards. If you are unsure how to start you can use a phrasebank [5] to copy nice formulations.
- If you are not sure if you found the right word in a dictionary use a single language dictionary like [4].
- Numbers: write words when referring to numerals below ten, referring to fractions, referring to approximate numbers and at the beginning of a sentence. Use figures when referring to sets of numbers, numbers including decimal points and when referring to pages. Make sure to use a decimal point instead of a comma as in German.
- Get yourself inspired from the literature. Use nice formulations from other papers. Never copy words but copy style.

It is very important to be consistently in wording and punctuation. Call the same things with the same name even if you think that it is boring. Use the same punctuation rule throughout the complete paper.

### D. Evaluation

You should always avoid to change the template. It was created for a good reason. If your manuscript is too long you should change the content and not the template. Concentrate on the purpose of your project and get rid of side aspects. Use references and keep work of others short. You HAVE to learn to describe your work in a given length. A rule of thumb is a partitioning of 15 % (Introduction), 40 % (Methods), 10 % (Results), 25 % (Discussion) and 10 % (Summary and outlook).

### E. Subsection

Normally, you don't present source code. The reader is more interested in a flow chart to understand how your algorithm works. Describe the most important steps of algorithms in detail and briefly describe other parts. Always provide a version when referring to other software packages or libraries. If you talk devices like smart phones or treadmills provide the manufacturer and the companies headwater details like (Google Inc., Mountain View, USA).

TABLE I. THE CAPTION IN TABLES HAS TO BE SELF EXPLAINING LIKE IN FIGURES (SEE FIG. 1). MAKE SURE TO EXPLAIN ALL ABBREVIATIONS THAT YOU USE IN THE CAPTION.

| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RULE | 0.5 | 0.7 | 0.3 | 0.7 | 0.8 | 0.2 | 0.3 | 0.5 | 0.7 | 0.9 |
| EPIC | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |

## III. RESULTS

You describe the pure results in this section. Performance measures, reference system and experimental setup have to be explained in the methods part. Don't provide an interpretation of the results in this section, just talk about the results. Don't provide reasons why your system didn't work in this or that condition. Just mention that this was the case. Quantitative results are most striking and you might want to sum them up in a table (Tab. I). If you have a lot of different results, pick the best and most important ones. Focus on the purpose of your system! You can use the same structure as in the methods section if appropriate.
The result section is written in simple past. Even if you have a live system, you describe the results as achieved in the evaluation.

## IV. DISCUSSION

Begin with a short problem specific summary. Discuss every aspect from the result section and give an interpretation of the results. You can use the same structure as in the results. Why is the algorithm so good/bad? What are limitations or assumptions? What was remarkable in the project and can be seen in the data. Make sure to cite the literature when comparing to existing systems or algorithms. Always mention pros and cons! Discuss global strength and weakness and concentrate on major aspects.
The discussion is mainly written in simple past. You can use present tense when talking about facts that you are absolutely sure about. If you are very self confident, you can deduce facts from your findings but often conditional formulations are more polite. Sometimes it is better to combine the discussion with an outlook so you might want to use future as well.

## V. SUMMARY AND OUTLOOK

Sum up the most important project findings and mention what the next steps, improvements, enhancements could be. The outlook can consist of ideas that will be hard to realize. Don't just think about tomorrow, think about the next ten years. You can finish with advertising your work and point out the most important finding or development again.
The summary part is written in simple past. The outlook is written in present tense or future.

## ACKNOWLEDGMENT

The authors would like to thank...

## REFERENCES

[1] Cook, G. et al.: *Pre-Participation Screening: The Use of Fundamental Movements as an Assessment of Function - Part 1*. North American Journal of Sports Physical Therapy 1(2), 62–72 (2006)

[2] Kugler, P. et al.: *Mobile Recording System for Sport Applications*. In: Proc. of the 8th International Symposium on Computer Science in Sport (IACSS2011) , pp. 67–70, Shanghai (2011)

[3] Theodoridis, S. and Koutroumbas, K.: Pattern Recognition. Academic Press (2008)

[4] Longman Dictionary http://www.ldoceonline.com/. Last visited: 16.09.2013 (2013)

[5] Academic Phrasebank http://www.phrasebank.manchester.ac.uk//. Last visited: 16.09.2013 (2013)