Schedule

- **18 April** – Talk: “How to read an academic paper”
- **19 April** – Notification about seminar assignment
- **Till 22 April (23:59)** Send your 3 preferred topics to mhaberma@mpi-inf.mpg.de
  
  **Example:**
  
  Marc Habermann, 2385768
  1) Physics-based Motion Modeling
  2) Interval Arithmetic Meets Implicit Surfaces
  3) Light Fields

  **For two students with equal preference -> first comes first serves**

- **23 April** – Topic assignments will be announced via email
- **25 April** – Talk: “How to give a good talk”
- **1 May 8am** – Send the questions for the two papers to rdabral@mpi-inf.mpg.de
- **2 May** – First student presentation (since only limited preparation time -> Bonus grade: 0.3)
Thank you!
Questions?
How to Read Academic Papers

Dr. Vladislav Golyanik, MPI for Informatics

Classical Concepts of Computer Vision and Computer Graphics in the Neural Age

Seminar – Summer Term 2024
Overview

- Reasons to Publish
- Scientific Papers and Their Types
- The Reviewing Process
- Paper Structure
- How to Read a Technical Paper
- The Three-Pass Approach

We introduced a new fully-neural approach for 3D human motion capture from monocular RGB videos with hard physics-based constraints which runs at interactive frame rates and achieves state-of-the-art results on multiple metrics. Our neural physical model allows learning motion priors and the associated physical properties, as well as gain values of the neural PD controller from data. Thanks to the custom neural layer, which expresses hard physics-based constraints, our architecture is fully-differentiable. In addition, it can be trained jointly on several datasets thanks to the new form of input canonicalization. Our experiments demonstrate that compared to PhysCap—a recent method with physics-based boundary conditions—our physiological approach captures significantly faster motions, while being more accurate in terms of various 3D reconstruction metrics. Thanks to the full differentiability, the proposed method can be fine-tuned on datasets with 2D annotations only, which improves the reconstruction fidelity on in-the-wild footages. These properties make it well suitable for direct virtual character animation from monocular videos, without requiring any further post-processing of the estimated global 3D poses.
Today’s Instructor: Dr. Vladislav Golyanik
Affiliation: 4DQV at VCAI Dep./ MPI for Informatics
Contact: golyanik@mpi-inf.mpg.de
Research Interests:
- 3D/4D Reconstruction and Neural Rendering
- 3D Generative Models
- Quantum Computer Vision

Photo taken by Marion Fregeac
In the last 5-10 years we have witnessed that deep learning has revolutionized Computer Vision, conquering the main scene in most vision conferences. However, a number of problems and topics for which deep-learned solutions are currently not preferable over classical ones exist, that typically involve a strong mathematical model (e.g., camera calibration and structure-from-motion).

This workshop concentrates on algorithms and methodologies that address Computer Vision problems in a “traditional” or “classic” way, in the sense that analytical/explicit models are deployed, as opposed to learned/neural ones. A particular focus will be given to traditional approaches that perform better than neural ones (for instance, in terms of generalization across different domains) or that, although performing sub-par, provide clear advantages with respect to deep learning solutions (for instance, in terms of efforts to collect data, computational requirements, power consumption or model compactness).

This workshop also encourages critical discussions about preferring a traditional solution rather than a deep learning approach and also explores relevant questions about how to bridge the gap between learning and classic knowledge. We also expect an insightful discussion about ethical implications of traditional vision in comparison to deep learning approaches.

https://sites.google.com/view/tradicv/home
Scientific Papers vs Literary Fiction
Scientific Papers vs Literary Fiction

1) Tells a story
2) Covers wide range of topics
3) Written for general audience
4) Self-published (or by a publisher)
5) Less formal writing

Images: https://www.britannica.com/biography/William-Shakespeare/Shakespeare-the-poet-and-dramatist (left)
Mildenhall et al., Communications of the ACM, 2021. (right)
Scientific Papers vs Literary Fiction

1) Conveys scientific findings
2) Written to experts in the field
3) Uses technical language
4) Published in peer-reviewed venues
5) Certain structure is expected

1) Tells a story
2) Covers wide range of topics
3) Written for general audience
4) Self-published (or by a publisher)
5) Less formal writing

Images: https://www.britannica.com/biography/William-Shakespeare/Shakespeare-the-poet-and-dramatist (left)
Mildenhall et al., Communications of the ACM, 2021. (right)
The Primary Questions

Q: **Why** are papers published?
Q: **What** is the structure of papers?
Q: **How** to read academic papers?
The Primary Questions

Q: **Why** are papers published?
Q: **What** is the structure of papers?
Q: **How** to read academic papers?

A: *It depends!*
Q: Why are papers published?
Q: What is the structure of papers?
Q: How to read academic papers?

A: It depends!

The reasons why a paper is published influence its structure. The structure influences how the paper is read and perceived.
Reasons to Publish

• Communication [of X] in a well structured form
• Documentation of work (math is the most precise language)
• Unpublished = Does not Exist
• Poor research should not be published
Reasons to Publish

- Communication [of X] in a well structured form
- Documentation of work (math is the most precise language)
- Unpublished = Does not Exist
- Poor research should not be published

\[ X = \begin{cases} 
\text{new ideas, theories, algorithms, neural architectures} \\
\text{solutions to existing (e.g., long-standing) and new problems} \\
\text{combinations of components (existing and new)} \\
\text{current state of the art} \\
\text{opinion on a certain topic} 
\end{cases} \]
## Paper and Publication Types

<table>
<thead>
<tr>
<th>Full paper</th>
<th>Journal Article</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conference Paper (Proceedings)</td>
<td>Workshop Paper</td>
</tr>
</tbody>
</table>
Paper and Publication Types

- Full paper
- Journal Article
- Conference Paper (Proceedings)
- Workshop Paper

quality
predicted impact
Paper and Publication Types

- Full paper
- Journal Article
- Conference Paper (Proceedings)
- Workshop Paper

More types?

quality predicted impact
Paper and Publication Types

Full paper
- Journal Article
- Conference Paper (Proceedings)
- Workshop Paper

Short paper
- Survey/STAR
- Opinion
- Technical Report (e.g., on arXiv)

More types?
- Corrigendum
- Dissertation
- Book
- Textbook
Academic Writing

papers → surveys → textbooks

postgraduate degree and research

high school and undergraduate degree
Research and Papers

Understand other people’s research → Do your research → Write up your research

Papers

Image by Weipeng Xu
The Reviewing Process

back then
The Reviewing Process

2000+ papers at CVPR each year

~20k pages

back then
The Reviewing Process

2000+ papers at CVPR each year

~20k pages

+ ACM SIGGRAPH, Eurographics, ICCV, ECCV, BMVC, GCPR, NeurIPS, ICLR, TPAMI, IJCV...

back then
The Reviewing Process

The decision process (overview)

1. PC assigns paper to AC
2. Primary AC suggests ~8 reviewers, algorithm (with PC oversight) assigns to you.
3. Reviews go to authors (after AC checking for quality)
4. Authors provide rebuttal to ACs and reviewers
5. Reviewers update final reviews
6. Area chairs discuss with reviewers, meet, deliberate, and make accept/reject decisions and oral/spotlight recommendations
7. Program chairs finalize spotlight/oral decisions based on space/time constraints

Reviewers (you and two others)
Primary Area Chair
Secondary Area Chair(s)
Program Chairs
Authors

Image Source: How to write good reviews for CVPR, by CVPR 2019 Program Chairs
Paper Structure

Shimada et al., SIGGRAPH 2021.
Paper Structure

Title / Header

Abstract

1. Introduction

2. Related Work

3. Method

4. Experiments

5. Conclusions

Acknowledgements

References

Appendix

Shimada et al., SIGGRAPH 2021.
Paper Structure

Title / Header
Abstract
1. Introduction
2. Related Work
3. Method
4. Experiments
5. Conclusions
Acknowledgements
References
Appendix
Video Poster
Webpage
Source Code

Neural Monocular
3D Human Motion Capture with Physical Awareness

Soshi Shimada, Vladislav Golyanik, Weipeng Xu, Patrick Pérez, Christian Theobalt

1Max Planck Institute for Informatics, Visual Computing and Artificial Intelligence Department
2 Saarland Informatics Campus,
3 Facebook Reality Labs,
4 VaSai
Abstract
1. Introduction
2. Related Work
3, 4, 5. Method
6. Results
   6.1 Datasets
   6.2 Comparisons
   6.3 Discussion
7. Conclusion
Acknowledgements

Mildenhall et al., Communications of the ACM, 2021.
Abstract

Marker-less 3D human motion capture from a single colour camera has seen significant progress. However, it is a very challenging and severely ill-posed problem. In consequence, even the most accurate state-of-the-art approaches have significant limitations. Purely kinematic formulations on the basis of individual joints or skeletons, and the frequent frame-wise reconstruction in state-of-the-art methods greatly limit 3D accuracy and temporal stability compared to multi-view or marker-based motion capture. Further, captured 3D poses are often physically incorrect and biomechanically implausible, or exhibit implausible environment interactions (floor penetration, foot skating, unnatural body leaning and strong shifting in depth), which is problematic for any use case in computer graphics.

We, therefore, present PhysCap, the first algorithm for physically plausible, real-time and marker-less human 3D motion capture with a single colour camera at 25 fps. Our algorithm first captures 3D human poses purely kinematically. To this end, a CNN infers 2D and 3D joint positions, and subsequently, an inverse kinematics step finds space-time coherent joint angles and global 3D pose. Next, these kinematic reconstructions are used as constraints in a real-time physics-based pose optimiser that accounts for environment constraints (e.g., collision handling and floor placement), gravity, and biophysical plausibility of human postures. Our approach employs a combination of ground reaction force and residual force for plausible root control, and uses a trained neural network to detect foot contact events in images. Our method captures physically plausible and temporally stable global 3D human motion, without physically implausible postures, floor penetrations or foot skating, from video in real time and in general scenes. PhysCap achieves state-of-the-art accuracy on established pose benchmarks, and we propose new metrics to demonstrate the improved physical plausibility and temporal stability.

Shimada et al., SIGGRAPH ASIA 2020.
Abstract

Marker-less 3D human motion capture from a single colour camera has seen significant progress. However, it is a very challenging and severely ill-posed problem. In consequence, even the most accurate state-of-the-art approaches have significant limitations. Purely kinematic formulations on the basis of individual joints or skeletons, and the frequent frame-wise reconstruction in state-of-the-art methods greatly limit 3D accuracy and temporal stability compared to multi-view or marker-based motion capture. Further, captured 3D poses are often physically incorrect and biomechanically implausible, or exhibit implausible environment interactions (floor penetration, foot skating, unnatural body leaning and strong shifting in depth), which is problematic for any use case in computer graphics.

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Shimada et al., SIGGRAPH ASIA 2020.
Abstract

Motion segmentation is a challenging problem that seeks to identify independent motions in two or several input images. This paper introduces the first algorithm for motion segmentation that relies on adiabatic quantum optimization of the objective function. The proposed method achieves on-par performance with the state of the art on problem instances which can be mapped to modern quantum annealers.
Conclusions

We introduced a new fully-neural approach for 3D human motion capture from monocular RGB videos with hard physics-based constraints which runs at interactive framerates and achieves state-of-the-art results on multiple metrics. Our neural physical model allows learning motion priors and the associated physical properties, as well as gain values of the neural PD controller from data. Thanks to the custom neural layer, which expresses hard physics-based constraints, our architecture is fully-differentiable. In addition, it can be trained jointly on several datasets thanks to the new form of input canonicalisation. Our experiments demonstrate that compared to PhysCap—a recent method with physics-based boundary conditions—our physionical approach captures significantly faster motions, while being more accurate in terms of various 3D reconstruction metrics. Thanks to the full differentiability, the proposed method can be finetuned on datasets with 2D annotations only, which improves the reconstruction fidelity on in-the-wild footages. These properties make it well suitable for direct virtual character animation from monocular videos, without requiring any further post-processing of the estimated global 3D poses.

We believe that the proposed method opens up multiple directions for future research. Our architecture can be classified as a 2D keypoint lifting approach, which has both advantages (e.g., the possibility of 2D keypoint normalisation, on the one hand) and downsides (e.g., reliance on the accuracy of 2D keypoint detectors, on the other). Next, our results naturally lead to the question of what is the most effective way to integrate physics-based boundary conditions in neural architectures, and how the proposed ideas can be applied to many related problem settings.

Shimada et al., SIGGRAPH ASIA 2020.
Introduction

• What is the problem?
• Why is it important and difficult?
• Drawbacks of previous approaches
• How? Key aspects of the proposed approach

• Possible locations for contributions:
  • Towards the end of the Intro section
  • At the end of the Related Work section
  • At the end of the Overview of the Method section

Shimada et al., SIGGRAPH 2021.
Related Work

- Purpose: The authors **showcase their expertise** in the field.
- One the one hand: **RW is not a history of the field and not a survey**
- On the other hand: **RW is not a simple enumeration!**
- Possible structure: Centred around the criteria of the main contributions
- Categorises and classifies works; **a “cone-like” structure is common.**
- Often discusses works related to the proposed approach and states 1) which ones are most closely related and 2) **in which aspects the paper at hand differs from them.**

Images: ![Image 1](https://www.science.org/content/article/how-seriously-read-scientific-paper)
![Image 2](https://pngtree.com/freebackground/pile-of-papers-on-a-table_3180731.html)
Method Section

3.4.3 Forward Dynamics. To introduce the laws of physics in our 3D motion capture algorithm, we embed the forward dynamics layer in our architecture. We derive joint accelerations $\ddot{q}$ from Eq. (2):

$$
\ddot{q} = M^{-1}(q)(\mathbf{r}^e + J^T \mathbf{G} \ddot{\mathbf{a}} - \mathbf{h}),
$$

where $\mathbf{r}^e = \mathbf{r} - J^T \mathbf{G} \ddot{\mathbf{a}}$. In this formulation, $\mathbf{r}^e$ expresses the minimised direct root actuation with contact force compensation for each joint torque. This forward dynamics layer returns $\ddot{q}$ considering mass matrix of the body $M$, internal and external forces, gravity, Coriolis and centrifugal forces encompassed in $\mathbf{h}$.

Fig. 2. Overview of our physically-inspired approach for markerless monocular 3D human motion capture. Our architecture assumes 2D keypoints in two representations as input, i.e., the canonicalised 2D keypoints ($\mathbf{K}_c$) and root-relative 2D keypoints normalised by the image size ($\mathbf{K}_{rt}$). These representations are complementary and ensure that joint angles and root orientation can be accurately estimated (thanks to $\mathbf{K}_{rt}$) along with the global translation, with no dependency on the camera intrinsics (thanks to $\mathbf{K}_c$). First, the target kinematic pose $\ddot{q}$ is regressed with TPNet and fed to the dynamic cycle which implements various types of physics-based boundary conditions. The dynamic cycle includes several neural components. The input to DyNet is a set of parameters (the target pose $\ddot{q}$, the current pose $q_0$, the current velocity $\dot{q}_t$), the mass matrix $M$ and the current pose error $\varepsilon_0 = d(\ddot{q}, \dot{q}_0)$ and the outputs are gain parameters $k_p$ of the PD controller and the offset force $\alpha$ for each DoF. The outputs from TPNet and DyNet are used to compute the force vector $\mathbf{r}$ following the PD controller rule. The GRFNet estimates the ground reaction force $\lambda$. Both $\mathbf{r}$ and $\lambda$ are then passed to the forward dynamics module which regresses the accelerations $\ddot{q}$ in the skeleton frame. This module considers mass matrix of the body $M$, internal and external forces, gravity, Coriolis and centrifugal forces. Finally, the character’s pose is updated using the obtained $\ddot{q}$ through the differentiable optimisation layer to prevent foot-floor penetration.

Fig. 3. Schematic visualisation of the friction cone and the ground reaction force at the foot-floor contact position.
Tables, plots, qualitative visualisations...

- Evaluation methodology/performance metrics
- Datasets used for the evaluation
- Implementation details and processing time

- Experimental results and their interpretation
- Probably Discussion (different from interpretation!)

Table 4. 2D projection error of a frontal view (input) and side view (non-input) on DeepCap dataset [Habermann et al. 2020].

<table>
<thead>
<tr>
<th></th>
<th>Front View</th>
<th>Side View</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$c_{2D}^{\text{input}}$ [pix]</td>
<td>$c_{2D}^{\text{side}}$ [pix]</td>
</tr>
<tr>
<td>Ours</td>
<td>7.6</td>
<td>11.5</td>
</tr>
<tr>
<td>PhysCap</td>
<td>21.1</td>
<td>35.5</td>
</tr>
<tr>
<td>VNect</td>
<td>14.3</td>
<td>37.2</td>
</tr>
</tbody>
</table>

Shimada et al., SIGGRAPH 2021.
Scientific Writing

Main principles:

Objectivity
Precision
Clarity
Efficiency
Scientific Writing

Main principles:

- Each discipline follows its set of rules, conventions and best practices
- Focus is on information
- Scientific arguments are built solely on evidence and logic and do not include emotions or opinions
- Scientists want their readers to draw the same conclusions from the evidence that they did; they, therefore, must present their chain of logic as clearly as possible
- Readers want to be able to easily evaluate the validity of results and conclusions, using the evidence they have before them
- All sources must be cited

Source: https://crk.umn.edu/sites/crk.umn.edu/files/science-writing.pdf
Questions to Ask While Reading

- What is the paper trying to convey?
- Why are the research and the obtained results significant?
- How were the results evaluated/measured?
- What were the results?
- What is the conclusion, and why?
- Do I trust the findings?
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- Do I trust the findings?

Be Critical!
Ask questions!
How to Read a Technical Paper

Q: What is your goal (when to stop)?
How to Read a Technical Paper

Q: What is your goal (when to stop)?

→ To see qualitative results  
  skim trough the paper
→ To learn what it is about  
  + read Abstract, Conclusions and Discussion
→ To understand the main idea  
  + read Introduction
→ To understand most details  
  + read Method and Experimental sections
* To understand in detail how it relates to previous methods  
  + read Related Work
The Three-Pass Approach

How to Read a Paper

S. Keshav
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Waterloo, ON, Canada
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ABSTRACT
Researchers spend a great deal of time reading research papers. However, this skill is rarely taught, leading to much wasted effort. This article outlines a practical and efficient three-pass method for reading research papers. I also describe how to use this method to do a literature survey.

Categories and Subject Descriptors: A.1 [Introductory and Survey]

General Terms: Documentation.
Keywords: Paper, Reading, Hints.

1. INTRODUCTION
Researchers must read papers for several reasons: to review them for a conference or a class, to keep current in their field, or for a literature survey of a new field. A typical researcher will likely spend hundreds of hours every year

4. Glance over the references, mentally ticking off the ones you’ve already read

At the end of the first pass, you should be able to answer the five Cs:

1. Category: What type of paper is this? A measurement paper? An analysis of an existing system? A description of a research prototype?

2. Context: Which other papers is it related to? Which theoretical bases were used to analyze the problem?

3. Correctness: Do the assumptions appear to be valid?

4. Contributions: What are the paper’s main contributions?

5. Clarity: Is the paper well written?

The Three-Pass Approach

2.1 The first pass

The first pass is a quick scan to get a bird's-eye view of the paper. You can also decide whether you need to do any more passes. This pass should take about five to ten minutes and consists of the following steps:

1. Carefully read the title, abstract, and introduction
2. Read the section and sub-section headings, but ignore everything else
3. Read the conclusions
4. Glance over the references, mentally ticking off the ones you've already read

2.2 The second pass

In the second pass, read the paper with greater care, but ignore details such as proofs. It helps to jot down the key points, or to make comments in the margins, as you read.

1. Look carefully at the figures, diagrams and other illustrations in the paper. Pay special attention to graphs. Are the axes properly labeled? Are results shown with error bars, so that conclusions are statistically significant? Common mistakes like these will separate rushed, shoddy work from the truly excellent.
2. Remember to mark relevant unread references for further reading (this is a good way to learn more about the background of the paper).
2.3 The third pass

To fully understand a paper, particularly if you are reviewer, requires a third pass. The key to the third pass is to attempt to virtually re-implement the paper: that is, making the same assumptions as the authors, re-create the work. By comparing this re-creation with the actual paper, you can easily identify not only a paper’s innovations, but also its hidden failings and assumptions.

This pass requires great attention to detail. You should identify and challenge every assumption in every statement. Moreover, you should think about how you yourself would present a particular idea. This comparison of the actual with the virtual lends a sharp insight into the proof and presentation techniques in the paper and you can very likely add this to your repertoire of tools. During this pass, you should also jot down ideas for future work.

This pass can take about four or five hours for beginners, and about an hour for an experienced reader. At the end of this pass, you should be able to reconstruct the entire structure of the paper from memory, as well as be able to identify its strong and weak points. In particular, you should be able to pinpoint implicit assumptions, missing citations to relevant work, and potential issues with experimental or analytical techniques.

- Attempt to virtually re-implement the paper
- Requires high attention to detail
- Enables identifying strong and weak points
- Takes up to multiple hours
Remember What You Read

- Make notes while reading papers
- Keep track of papers in a written form (title, authors, venue, link, the main idea)
- Write a summary of the most relevant papers
- Use reference managers
Conclusion

- Papers convey scientific findings and are written for experts
- Papers differ in their type and quality
- Published papers are peer-reviewed
- Papers have a predefined (conventional) structure
- Principles of scientific writing: objectivity, precision, clarity, efficiency
- The three-pass approach
- How to read a paper depends on the goal

Be Critical!
Ask questions!

THE THREE-PASS APPROACH
The key idea is that you should read the paper in up to three passes, instead of starting at the beginning and plowing your way to the end. Each pass accomplishes specific goals and builds upon the previous pass: The first pass gives you a general idea about the paper. The second pass lets you grasp the paper’s content, but not its details. The third pass helps you understand the paper in depth.
Questions?

- Objectivity
- Precision
- Clarity
- Efficiency