

Towards The Classification of Human Movement Variability in Dance Activities Using NAO as an Instructor

XXX XXX^{*}
University of XXX
XXX,XXX
xxx@xxx.xxx

XXX XXX[†]
University of XXX
XXX,XXX
xxx@xxx.xxx

XXX XXX[‡]
University of XXX
XXX,XXX
xxx@xxx.xxx

ABSTRACT

This paper provides ...

CCS Concepts

•Computer systems organization → External interfaces for robotics;

Keywords

Humanoid dance robot, movement variability

1. INTRODUCTION

The use of humanoid-robots has been increasing for training and demonstration of dance movements. For instance, Fung *et al.* made movement comparison of two low-cost humanoid robots for implementation and demonstration of simple Thai dance activities [4]. Xia *et al.* implemented automatic humanoid-robot dancing with NAO which is driven by the beats and emotions of the music [12]. Similarly, NAO acted as a tutor to guide 10 children to teach dance with the *concept-based learning* in which the robot guides the child thorough different stages of dance across three sessions [8]. Additionally, Ros *et al.* explored three different learning models to design a robot dance tutor: i) Sequence-Based Model; (ii) Concept-Based Model; and (iii) Relational-Based Model [9]. In the same vein of dancing with robots, *Keepon*, a non-humanoid-robot, showed a positive effect on the children's rhythmic behavior. For example, some children tried to make the robot synchronise its movements to the music, some other children exaggeratedly danced to the music when the robot was not synchronised; while other children imitate robot's movements to the point of ignoring the musical rhythm, and one important behavior was that the synchrony of the children with the music was more prevalent than the

robot movement [7]. Tsuchida *et al.* explored the dancing feeling with an actual dancer in four scenarios (dancing with a dancer, dancing alone, dancing with a self-propelled robot and dancing with a projected video) of which they managed to make people feel like they were dancing with a dancer when dancing with a self-propelled robot and dancing with a projected video [11].

However, none of the previous works have been analysed the movement of the participants to which we are proposing the use of NAO and inertial sensors attached to the persons to analyse the movement variability in simple dance activities. With this, we believe that the outcome can help us to quantify the level of dexterity of dancers as well as provide feedback to dance better.

2. RELATED WORK

Typically, the body of a paper is organized into a hierarchical structure, with numbered or unnumbered headings for sections, subsections, sub-subsections, and even smaller sections. The command `\section` that precedes this paragraph is part of such a hierarchy.¹ L^AT_EX handles the numbering and placement of these headings for you, when you use the appropriate heading commands around the titles of the headings. If you want a sub-subsection or smaller part to be unnumbered in your output, simply append an asterisk to the command name. Examples of both numbered and unnumbered headings will appear throughout the balance of this sample document.

Because the entire article is contained in the `document` environment, you can indicate the start of a new paragraph with a blank line in your input file; that is why this sentence forms a separate paragraph.

2.1 Type Changes and Special Characters

We have already seen several typeface changes in this sample. You can indicate italicized words or phrases in your text with the command `\textit`; boldening with the command `\textbf` and typewriter-style (for instance, for computer code) with `\texttt`. But remember, you do not have to indicate typestyle changes when such changes are part of the *structural* elements of your article; for instance, the heading of this subsection will be in a sans serif² typeface,

¹This is the second footnote. It starts a series of three footnotes that add nothing informational, but just give an idea of how footnotes work and look. It is a wordy one, just so you see how a longish one plays out.

²A third footnote, here. Let's make this a rather short one to see how it looks.

*XXXX XXXXX XXXX XXXXX XXXX XXXXX XXXX XXXXX
†XXXX XXXXX XXXX XXXXX XXXX XXXXX XXXX XXXXX
‡XXXX XXXXX XXXX XXXXX XXXX XXXXX XXXX XXXXX

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

HRI '2017 Vienna, Austria

© 2016 ACM. ISBN 123-4567-24-567/08/06...\$15.00

DOI: 10.475/123.4

but that is handled by the document class file. Take care with the use of³ the curly braces in typeface changes; they mark the beginning and end of the text that is to be in the different typeface.

You can use whatever symbols, accented characters, or non-English characters you need anywhere in your document; you can find a complete list of what is available in the *L^AT_EX User's Guide*[6].

2.2 Math Equations

You may want to display math equations in three distinct styles: inline, numbered or non-numbered display. Each of the three are discussed in the next sections.

2.2.1 Inline (In-text) Equations

A formula that appears in the running text is called an inline or in-text formula. It is produced by the **math** environment, which can be invoked with the usual **\begin. . . \end** construction or with the short form **\$. . . \$**. You can use any of the symbols and structures, from α to ω , available in L^AT_EX[6]; this section will simply show a few examples of in-text equations in context. Notice how this equation: $\lim_{n \rightarrow \infty} x = 0$, set here in in-line math style, looks slightly different when set in display style. (See next section).

2.2.2 Display Equations

A numbered display equation – one set off by vertical space from the text and centered horizontally – is produced by the **equation** environment. An unnumbered display equation is produced by the **displaymath** environment.

Again, in either environment, you can use any of the symbols and structures available in L^AT_EX; this section will just give a couple of examples of display equations in context. First, consider the equation, shown as an inline equation above:

$$\lim_{n \rightarrow \infty} x = 0 \quad (1)$$

Notice how it is formatted somewhat differently in the **displaymath** environment. Now, we'll enter an unnumbered equation:

$$\sum_{i=0}^{\infty} x + 1$$

and follow it with another numbered equation:

$$\sum_{i=0}^{\infty} x_i = \int_0^{\pi+2} f \quad (2)$$

just to demonstrate L^AT_EX's able handling of numbering.

2.3 Citations

Citations to articles [1, 3, 2, 5], conference proceedings [3] or books [10, 6] listed in the Bibliography section of your article will occur throughout the text of your article. You should use BibTeX to automatically produce this bibliography; you simply need to insert one of several citation commands with a key of the item cited in the proper location in the .tex file [6]. The key is a short reference you invent to uniquely identify each work; in this sample document, the key is the first author's surname and a word from the title. This identifying key is included with each item in the .bib file for your article.

³A fourth, and last, footnote.

Table 1: Frequency of Special Characters

Non-English or Math	Frequency	Comments
Ø	1 in 1,000	For Swedish names
π	1 in 5	Common in math
\$	4 in 5	Used in business
Ψ_1^2	1 in 40,000	Unexplained usage



Figure 1: A sample black and white graphic.

The details of the construction of the .bib file are beyond the scope of this sample document, but more information can be found in the *Author's Guide*, and exhaustive details in the *L^AT_EX User's Guide*[6].

This article shows only the plainest form of the citation command, using **\cite**. This is what is stipulated in the SIGS style specifications. No other citation format is endorsed or supported.

2.4 Tables

Because tables cannot be split across pages, the best placement for them is typically the top of the page nearest their initial cite. To ensure this proper “floating” placement of tables, use the environment **table** to enclose the table's contents and the table caption. The contents of the table itself must go in the **tabular** environment, to be aligned properly in rows and columns, with the desired horizontal and vertical rules. Again, detailed instructions on **tabular** material is found in the *L^AT_EX User's Guide*.

Immediately following this sentence is the point at which Table 1 is included in the input file; compare the placement of the table here with the table in the printed dvi output of this document.

To set a wider table, which takes up the whole width of the page's live area, use the environment **table*** to enclose the table's contents and the table caption. As with a single-column table, this wide table will “float” to a location deemed more desirable. Immediately following this sentence is the point at which Table 2 is included in the input file; again, it is instructive to compare the placement of the table here with the table in the printed dvi output of this document.

2.5 Figures

Like tables, figures cannot be split across pages; the best placement for them is typically the top or the bottom of the page nearest their initial cite. To ensure this proper “floating” placement of figures, use the environment **figure** to enclose the figure and its caption.

This sample document contains examples of .eps files to be displayable with L^AT_EX. If you work with pdfL^AT_EX, use files in the .pdf format. Note that most modern T_EX system will convert .eps to .pdf for you on the fly. More details on each of these is found in the *Author's Guide*.

As was the case with tables, you may want a figure that spans two columns. To do this, and still to ensure proper “floating” placement of tables, use the environment **figure*** to enclose the figure and its caption. and don't forget to end

Table 2: Some Typical Commands

Command	A Number	Comments
<code>\alignauthor</code>	100	Author alignment
<code>\numberofauthors</code>	200	Author enumeration
<code>\table</code>	300	For tables
<code>\table*</code>	400	For wider tables



Figure 2: A sample black and white graphic that has been resized with the `includegraphics` command.

the environment with `figure*`, not `figure`!

2.6 Theorem-like Constructs

Other common constructs that may occur in your article are the forms for logical constructs like theorems, axioms, corollaries and proofs. There are two forms, one produced by the command `\newtheorem` and the other by the command `\newdef`; perhaps the clearest and easiest way to distinguish them is to compare the two in the output of this sample document:

This uses the **theorem** environment, created by the `\newtheorem` command:

THEOREM 1. *Let f be continuous on $[a, b]$. If G is an antiderivative for f on $[a, b]$, then*

$$\int_a^b f(t)dt = G(b) - G(a).$$

The other uses the **definition** environment, created by the `\newdef` command:

Definition 1. If z is irrational, then by e^z we mean the unique number which has logarithm z :

$$\log e^z = z$$

Two lists of constructs that use one of these forms is given in the *Author's Guidelines*.

There is one other similar construct environment, which is already set up for you; i.e. you must *not* use a `\newdef` command to create it: the **proof** environment. Here is an example of its use:

PROOF. Suppose on the contrary there exists a real number L such that

$$\lim_{x \rightarrow \infty} \frac{f(x)}{g(x)} = L.$$

Then

$$l = \lim_{x \rightarrow c} f(x) = \lim_{x \rightarrow c} \left[g(x) \cdot \frac{f(x)}{g(x)} \right] = \lim_{x \rightarrow c} g(x) \cdot \lim_{x \rightarrow c} \frac{f(x)}{g(x)} = 0 \cdot L = 0,$$

which contradicts our assumption that $l \neq 0$. \square

Complete rules about using these environments and using the two different creation commands are in the *Author's*

Guide; please consult it for more detailed instructions. If you need to use another construct, not listed therein, which you want to have the same formatting as the Theorem or the Definition[10] shown above, use the `\newtheorem` or the `\newdef` command, respectively, to create it.

A Caveat for the T_EX Expert

Because you have just been given permission to use the `\newdef` command to create a new form, you might think you can use T_EX's `\def` to create a new command: *Please refrain from doing this!* Remember that your L^AT_EX source code is primarily intended to create camera-ready copy, but may be converted to other forms – e.g. HTML. If you inadvertently omit some or all of the `\defs` recompilation will be, to say the least, problematic.

3. CONCLUSIONS

This paragraph will end the body of this sample document. Remember that you might still have Acknowledgments or Appendices; brief samples of these follow. There is still the Bibliography to deal with; and we will make a disclaimer about that here: with the exception of the reference to the L^AT_EX book, the citations in this paper are to articles which have nothing to do with the present subject and are used as examples only.

4. ACKNOWLEDGMENTS

This section is optional; it is a location for you to acknowledge grants, funding, editing assistance and what have you. In the present case, for example, the authors would like to thank Gerald Murray of ACM for his help in codifying this *Author's Guide* and the `.cls` and `.tex` files that it describes.

5. ADDITIONAL AUTHORS

Additional authors: John Smith (The Thørväld Group, email: jsmith@affiliation.org) and Julius P. Kumquat (The Kumquat Consortium, email: jpkumquat@consortium.net).

6. REFERENCES

- [1] M. Bowman, S. K. Debray, and L. L. Peterson. Reasoning about naming systems. *ACM Trans. Program. Lang. Syst.*, 15(5):795–825, November 1993.
- [2] J. Braams. Babel, a multilingual style-option system for use with latex's standard document styles. *TUGboat*, 12(2):291–301, June 1991.
- [3] M. Clark. Post congress tristesse. In *TeX90 Conference Proceedings*, pages 84–89. TeX Users Group, March 1991.
- [4] C. C. Fung and T. Nandhabiwat. Comparing Two Off-the-shelf Robots for the Demonstration of Thai Folk Dances: An Initial Study. *Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology*, pages 309–312, 2008.



Figure 3: A sample black and white graphic that needs to span two columns of text.

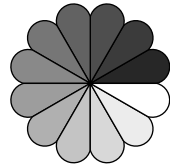


Figure 4: A sample black and white graphic that has been resized with the `includegraphics` command.

- [5] M. Herlihy. A methodology for implementing highly concurrent data objects. *ACM Trans. Program. Lang. Syst.*, 15(5):745–770, November 1993.
- [6] L. Lamport. *LaTeX User's Guide and Document Reference Manual*. Addison-Wesley Publishing Company, Reading, Massachusetts, 1986.
- [7] M. P. Michalowski, S. Sabanovic, and H. Kozima. A Dancing Robot for Rhythmic Social Interaction. *Human Robot Interaction*, pages 89–96, 2007.
- [8] R. Ros, A. Coninx, Y. Demiris, G. Patsis, V. Enescu, and H. Sahli. Behavioral accommodation towards a dance robot tutor. *Proceedings of the 2014 ACM/IEEE international conference on Human-robot interaction - HRI '14*, pages 278–279, 2014.
- [9] R. Ros and Y. Demiris. Creative dance: An approach for social interaction between robots and children. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 8212 LNCS:40–51, 2013.
- [10] S. Salas and E. Hille. *Calculus: One and Several Variable*. John Wiley and Sons, New York, 1978.
- [11] S. Tsuchida, T. Terada, and M. Tsukamoto. A system for practicing formations in dance performance supported by self-propelled screen. *Proceedings of the 4th Augmented ...*, 56(5):178–185, 2013.
- [12] G. Xia, J. Tay, R. Dannenberg, and M. Veloso. Autonomous robot dancing driven by beats and emotions of music. *Proceedings of the 11th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2012)*, pages 205–212, 2012.

APPENDIX

A. HEADINGS IN APPENDICES

The rules about hierarchical headings discussed above for the body of the article are different in the appendices. In the `appendix` environment, the command `section` is used to indicate the start of each Appendix, with alphabetic order designation (i.e. the first is A, the second B, etc.) and a title (if you include one). So, if you need hierarchical structure *within* an Appendix, start with `subsection` as the highest level. Here is an outline of the body of this document in Appendix-appropriate form:

A.1 Introduction

A.2 The Body of the Paper

A.2.1 Type Changes and Special Characters

A.2.2 Math Equations

Inline (In-text) Equations.

Display Equations.

A.2.3 Citations

A.2.4 Tables

A.2.5 Figures

A.2.6 Theorem-like Constructs

A Caveat for the T_EX Expert

A.3 Conclusions

A.4 Acknowledgments

A.5 Additional Authors

This section is inserted by L^AT_EX; you do not insert it. You just add the names and information in the `\addition-
alauthors` command at the start of the document.

A.6 References

Generated by bibtex from your `.bib` file. Run latex, then bibtex, then latex twice (to resolve references) to create the `.bbl` file. Insert that `.bbl` file into the `.tex` source file and comment out the command `\thebibliography`.

B. MORE HELP FOR THE HARDY

The sig-alternate.cls file itself is chock-full of succinct and helpful comments. If you consider yourself a moderately experienced to expert user of \LaTeX , you may find reading it useful but please remember not to change it.