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| **Type of Presentation:**  Oral | **Topic:**  Measurement in Robotics |

Dense convolutional neural for

the line shape prediction

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**Summary:** In this paper we presents dense convolutional neural network implementation for real time line sensor processing data on line following robot. We trained network for line shape prediction. Network is estimating the optimal speed for the line following robot – braking in curves, accelerating on straight line. Our implementation can run on limited resources, as small ARM Cortex M microcontrollers without FPU.

**Keywords:** deep learning, robotics, densenet, line follower, ARM Cortex

1. Introduction

Nárast aplikácií deep learning sa prejavuje nie len v doméne počítania na GPU (PC) [citovať], ale aj v malých zariadeniach ako sú Smart Phones, Tablets. Posledné roky dosiali malé mikrokontroléry (ARM Cortex M0 .. M7) dostatočný výkon pre beh konvolučných neurónových sieti [citovať].

Problémom môže byť platformovo závislá implementácia – výrobcovia poskytujú hotové neurónove siete [citovať], ale len pre ich zariadenia. Z hlbokých sieti sú často podporované len základné verzie konvolučných sieti, prípadne aj zastaralé architektúry ako AlexNet, a kernely 5x5, ktoré sú výpočtovo neefektívne [citovať].

Rozhodli sme sa pre implementáciu platformovo nezávislého frameworku, ktorý by podporoval aj najnovšie typy konvolučných sieti – DenseNet [citovať].

Optimalizácia takejto siete zahŕňǎ niekoľko krokov.  
Medzi ne patria : diskretizácia siete na 8 bitov, optimalizácia kernelov pre veľkosti 1x1, 3x3 a 3x1. Podpora poolingo iba veľkosti 2x2. Tieto náday boli prezentované už vo VGG sieti

Takáto sieť môže predspracovávať dáta priamo na mieste a rozšíriť tak možnosti IoT a embedded aplikácií.

Ako zaujímavú demonštračnú aplikáciu sme zvolili robota – line follower, kde sieť predikuje tvar zákruty a podľa toho určuje maximálnu prípustnú rýchlosť.

Sieť je schopná bežať v reálnom čase (odozva 2..3ms, na procesore ARM Cortex M4, 72MHz).

**1.1. Page Setup: Margins and Layout**

Use A4 (210 x 297 mm) sized paper of the article. Colum width must be 7.61 cm, spacing between columns must be 0.7 cm. In the Page Setup menu please select 'Mirror Margins' option in the 'Margins' submenu, Use 0.89 cm for Header and 1.27 cm for Footer. Leave 1.9 cm margins at the top and inside, and 2.54 cm at the bottom and outside. Gutter:   
0.63 cm. Please do not re-adjust these margins.

**1.2 Fonts, Size and Style**

The text should be typed double-spaced and justified. Use Times New Roman typeface throughout the article. Center the title (14 points, bold); author(s) name(s) (11 points, bold); affiliation(s), address(es), phone number and fax numbers (with country and city codes), and e-mail address (9 points, regular). Leave one blank lines above the title and affiliations.

Then put short abstract of the article (approximately 150 words, 9 points). For word **Abstract** use Bold. After the abstract insert one blank line.

Below insert a list of up to 5 keywords/ keyphrases. For the word **Keywords** use Bold.

Type the text of the article (10 points, regular) in two columns.

Use 0.5 cm indent in first line of each paragraph. Do not use the blank line between paragraphs. Headings must be numbered. (11 points, bold) and precede each of them with one blank line. Do not use Roman numbers. Use 10 point, bold for subheads.

Place a full list of references at the end of the article. Please place the references according to their order of appearance in the text. Enclose the numbers in square brackets. Use 9 points, regular for the reference list. A reference must include a full title of article, paper or book, and journal title and conference proceedings for articles and papers. Please use the full titles for journals.

Paragraph format: spacing before 0 pt, after 0 pt, line spacing: single.

**1.3 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, IFSA, ac, dc, ms, etc. do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

2. Equations

**2.1. This is a Subtitle Example**

Equations should be prepared in Equation Editor and placed in separate lines, numbered and centered. Please use separate table's cells to place an equation and its number. Do not use any equations inside of paragraph. The numbers should be within brackets and right aligned. Leave one blank line above and below each equation. For example, the line equaton:

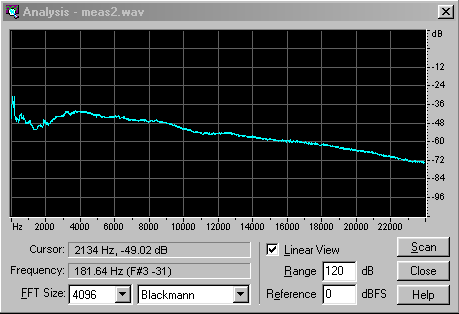
|  |  |  |
| --- | --- | --- |
|  | , | (1) |

where is the coefficient, *x* is the argument and is the bias.

**3. Figures and Tables**

The figures and tables must be numbered, have a self-contained caption and centered. **Please note, all figures and tables must be referred in the text before the first appearance.** Figure captions should be below the figures; table captions should be above the tables. Please avoid placing figures and tables before their first mention in the text.

The text of figure captions should be 9 points high, Times New Roman. For the words “Fig.” and “Table” use Bold. For example: **Fig. 7,   
Table 5.** Leave two blank line before and one after text of figure and table captions.



**Fig. 1.** Example of figure. (maximal possible width   
for single-column figures is 7.6 cm).

Table captions should be centered or right aligned and figure captions should be centered. Leave two blank line before the caption of the table. Do not indent the captions. Do not use characters smaller than 8 point in figures.

All the figures, graphs and photographs should be numbered and referred in the main text. Abscissas and ordinates of all graphs should be labeled with symbols and units.All figures, graphs and photographs can be in colors as well as in black and white (or gray shades) with good resolution. Big size figures and tables can have the double-column width (see Fig. 2 as an example).

The table example is shown below.

**Table 1.** Title must be here.

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Um, (V)** | **Is, (mA)** | **kz** |
| 1. | 0.37 | 25 | 8.956 |
| 2. | 1.9 | 32 | 4.67 |

**Please check the numbering sequence of figures, tables, sections, formulas, etc. before submitting the paper.**

**4. Conclusions**

We thank you in advance for the usage carefully of instructions for camera-ready articles, which can be sent for publication with minor modification.

**Acknowledgements**

Use the Acknowledgements section if it is necessary.

**References**

**Please use Article title and full title for Journals. Dot not use abbreviations !**

Examples of references:

[1]. A. Author, Book title, Editor, *Publisher*, 1990.

[2]. S. Author, T. More. Title of the article, *Journal Title*, Vol. 5, Issue 2, 1995, pp. 10-15.

[3]. T. Scientist, Title of the paper, in *Proceedings of the Conference on 'Smart Sensors and Systems: Technology and Applications (SSS&TA’ 2003)’*, Paris, France, 16-19 March 2003, pp. 123-127.

[4]. Sensors Web Portal (http://www.sensorsportal.com).



**Fig. 2.** Example of double-column width figure.