Cellular neural/nonlinear networks with image processing and mobile robot navigation applications

Abstract

This habilitation thesis presents the main personal achievements obtained in scientific research, teaching and academic activity after getting the PhD degree at University Politehnica Timisoara (2001).

The habilitation thesis is structured as follows:

- the abstract, which includes the synthesis of the habilitation thesis, written both in Romanian and English;

- the second part, which covers the scientific professional and academic achievements, and future research and teaching career development plans;

- references.

The second part includes three chapters.

The first chapter briefly presents the main achievements in scientific research, teaching and academic work: courses taught, new subjects introduced in the curriculum and contributions to the development of curricula, mentoring diploma and dissertation projects, published papers list and grants / projects, equipped laboratories, visiting professor, initiating international academic collaboration, management activities, etc. Between 2001-2016 I have published 79 papers in scientific journals and at national and international workshops of which 27 are ISI indexed and other 24 are BDI indexed, I have written 6 books and 4 laboratory guides in fields related to the present thesis, I collaborated in 12 grants / research projects won by competition (in 5 of them being the project manager) and 4 research contracts with the socio-economic environment.

Chapter two covers the technical description of the scientific contributions obtained in the four research directions that were addressed by the author during the above-mentioned period of time:

▫ *Image processing based on variational computing and using of cellular neural/nonlinear networks.* Along with other classical methods, such as parallel computing structures, *Cellular Neural/Nonlinear Networks (CNN)* provides complementary solutions to achieve real-time signal processing applications. An original template design method based on variational computing is presented, which can be used to perform certain spatio-temporal processing of images. Using templates designed in this manner, the effectiveness of these CNN methods was analyzed in reconstruction a damaged or partially known image and a homogeneous CNN algorithm was developed for motion estimation and compensation.

▫ *Medical image processing.* CNN implementation of methods for medical image processing is not an aim by itself, but obtaining solutions to their integration into a real-time medical diagnosis support system and/or follow-up treatment. Original CNN methods are presented for adaptive contrast enhancement, noise filtering, segmentation of medical images, particularly computer tomography (CT) images, offering increased visibility of

image components in order to help the expert make the best possible interpretation of the image. Also the results of the study regarding the use of Gabor filters in the classification of normal, benign and malignant mammary tissue are presented. To reduce the size of the data *Principal Component Analysis (PCA)* was implemented, and as classifier the *Proximal Support Vector Machines* method was used.

▫ *Cellular neural networks technology using for autonomous navigation of mobile robots.* Using the CNN technology to mobile robot control, with on images based visual feedback, a reduction in processing time can be achieved and thus a movement speed increase can be obtained. The CNN path planning algorithm for a mobile robot in an environment with obstacles to find an optimal trajectory in terms of length and number of turns between the start and target positions. The proposed method can be extended to the case of simultaneous navigation of two of mobile robots and also to coordinate the movement of a collective of mobile robots. Thus, each robot avoids obstacles in its path as well as the other robot. Finally, an integrated system for effective self-propelled mobile robot in a real unstructured environment is presented. A hybrid method for robot navigation is proposed that takes into account the optimal combination of the two complementary types of navigations, e.g the global and local method.

▫ *Integrated system for assisting visually impaired people.* Based on the spectacular evolution of electronic technology, the development of a new integrated system for assisting visually impaired people in some typical every-day tasks. To increase the efficiency of this system, a CNN algorithm is proposed for calculating the correlation between two images. This algorithm has been implemented, in a semi-parallel version, on an emulated digital *FPGA* based platform of a *CNN-UM (CNN Universal Machine)*. The proposed semi-parallel implementation variant yields an optimal ratio between processing speed and required hardware resources.

It has to be noted that most topics, grouped into four directions of research were addressed in national or international grants/research projects, where my role was a principal investigator or member of a research team. The main obtained results in connection with these directions of research have been published in 60 articles, of which 25 are ISI indexed papers and 20 papers are BDI indexed.

The last section presents scientific, academic and professional career development plans, and methods envisaged to effective achievement of these objectives. Under the "applied electronic systems" head line, the main direction of research refers to the development of biomedical signal analysis and processing methods and their effective implementation in a real-time medical diagnosis helping follow-up treatment. The investigation of CT and mammographic images will be continued, alongside *cellular wave computing* and other new implementations.