Proposed topics for Hungarian-Israeli research and innovation cooperation

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1. Robust Control of Type I Diabetes

Diabetes mellitus is one of the most serious diseases which need to be artificially regulated. Due to patients diversity (different personal parameters) the optimization of the insulin dosage is hard to done without reconfiguring the controller.

Robust control methods enable to "generalize" somehow the applicability of the designed controller especially due to the neglected dynamics, modeling simplifications, uncertainties. In case of Type I diabetes treatment this could be useful by keeping the lifestyle of the patient as well as optimizing the insulin amount (quality vs. cost problem). Several robust method algorithms developed here have been published already. Simulation results proved that the algorithms can be useful for example in personalizing the insulin pumps.

What is needed?

- Completion of the basic research: comparison of different robust techniques
- Clinical tests

What result is expected:

- Optimal robust control method capable to personalize the insulin pumps.

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2. Cardiovascular risk estimation in case of infant obesity

The aim of the project is to conceptualize and implement a method which, based on simple measurements of the physical sizes of the human body, can conclude on the presence of atherogen fat, and thus can also give a risk estimation of cardiovascular problems. Although this connection is well-known in case of adult population, the research aims at children. The resulted criteria should be similar to BMI (Body Mass Index), but it will surely contain more than two variables.

What is needed?

- Lots of measurements on children (anthropometry, blood sample)
- Gold-standard measurements which are expensive (MRI, DXA)
- Classifying the obtained measurements, statistical mathematics, developing a general criteria
- Estimating cardiovascular risk based on the previously mentioned measurements

What result is expected:

- General criteria / classification for infants' cardiovascular risks.

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3. ECG processing and compression

The iteratively functioning multi-channel ECG processing and compression algorithm has a QRS detection rate above 99.9%. The high reliability of the developed system that realize a good balance among proper signal quality for diagnosis and high compression rate is yielded by a support vector machine based technique. Various applications of the developed method were published in several papers. In the development phase of the novel processing algorithm more than 1000 clinical measurements were used.

What is needed?

- Completion of the basic research: find the best parameters for each step of the processing and compression algorithm
- Development of the ECG processing software
- More clinical tests
- Some computers with high processing performance

What result is expected:

- Various kinds of ECG processing software
- A set of ECG processing methods that can outperform those used in clinical practice, suitable to be integrated into professional devices.

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4. Dynamic heart modeling

The developed dynamic heart model is capable to simulate in real-time various pathological phenomena, such as the life threatening ventricular fibrillation or Wolff-Parkinson-White syndrome. The simulation method is capable to modify adaptively the spatial and temporal resolution. The accuracy and efficiency of the algorithm was tested for anisotropic and inhomogeneous tissue. Using the parallelized implementation, it can be reached a speedup of factor 200. The data validation process is based on several hundred multi-channel ECG records and a huge amount echocardiographic image sequences.

What is needed?

- Basic research: find the best parameters for each step of the modeling algorithm
- Establish the best form of the parallel modeling method
- Development of the modeling software
- More clinical tests
- Some computers with high processing (CPU+GPU) performance
- Several 3D echocardiogram records

What result is expected:

- A real-time and complex spatial-temporal dynamic heart modeling software
- The introduction of this novel model in clinical practice

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5. Medical image processing – Virtual endoscope

Virtual endoscopy enables us to visualize the inner structure of the human body without actual penetration. Based upon images observed with different medical imaging techniques (MRI, PET, echo, etc.), a series of image processing algorithms (involving image enhancement and filtering, distortion removing transformations, segmentation and registration, 3D reconstruction) are performed in order to provide inner 3D surfaces, which are visualized using computer graphics applications. We have already developed and published several image filtering, registration and segmentation methods.

What is needed?

- Completion of the basic research: find the best algorithm for each image processing task (filtering, registration, segmentation, etc.)
- Development of the virtual endoscope software
- Several sets of recorded medical images
- Some computers with high graphical performance

What result is expected:

- A virtual endoscope software
- A set of image processing methods that can outperform those used in clinical practice, suitable to be integrated into professional imaging devices

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6. Accurate characterization of blood-pressure

Present techniques (including the most popular oscillometric one) give a momentary value for the blood-pressure of the tested person. This might be completely misleading as blood pressure can change beat-to-beat. Even this momentary value can be severely distorted.

We have developed a new measurement method and evaluation algorithm that gives more accurate results, and it warns if the patient is not in the resting state necessary for the measurement. More than 1500 non-invasive measurements have been taken. Two patients were tested in parallel with invasive measurement. The measurement method is being verified using cuff pressure simulator (accepted for testing devices).

What is needed?

- Completion of the basic research: set the parameters of the algorithm
- Development of a prototype device
- Clinical tests

What result is expected:

- A family of blood-pressure meters
- The simplest device outperforms the conventional home devices. More sophisticated devices can be personalized, they can assess the actual state of the arteries and augmented with ECG recording ability.

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7. Acoustic diagnosis of infant cry

An infants' cry contains several types of information about its state of health (e.g. Cri Du Chat Syndrome). By the acoustic analysis of these sounds our aim is to recognize diseases. It is a non-invasive method which needs only a microphone and a digital signal processing (DSP) unit, and helps to set the diagnosis. We have recorded and analysed around 3000 crying sounds from 280 infants during the last 7 years. We have developed new signal processing algorithms, a patented method to obtain and visualize the melody contour of crying sounds, and determined numerous attributes (qualitative and quantitative) of crying to categorize the sounds.

What is needed?

- Record more crying signals from special groups of infants
- Improve our existing algorithms to distinguish the acoustic characteristics of diseases of each other
- Develop a diagnostic software or an interactive web page containing these algorithms

What result is expected:

- A diagnostic software which gives information about the infants' state of health, using the analysis of a 40-50 seconds long crying signal. Later, the software could be upgraded by including more diseases.

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