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Program

Session 1. Chair: Bernhard Moser

9:00 Michael Zwick:

SymReg-TL: Iterative Multi-task Feature Learning Through Weighted Symbolic Regression

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Sparse Signal Processing Technique in Structural Health Monitoring

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10:15 Kurt Pichler:

Detecting broken reciprocating compressor valves in the pV diagram

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On the Performance of Master-Slave Parallelization Methods for Multi-Objective Evolutionary Algorithms

SYMREG-TL: Iterative Multi-task Feature Learning through Weighted Symbolic Regression

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Abstract

In *multi-task learning* [2], a variant of transfer learning [5], different but related tasks in the same feature space — for each of which (labeled) data is available — are learned simultaneously, with the goal of improving the performance of each task by incorporating knowledge from all other tasks. In our research, our goal is to learn regression models for related tasks which are similar in structure, i.e., they predominantly share the same features which represent the commonalities between the tasks, with only a small number of task-specific features that represent the differences between tasks.

We present a method to unify models of different but related tasks using a *multi-task feature learning* approach [1] based on *symbolic regression* [6]. The symbolic regression community usually relies on genetic programming [3] when implementing symbolic regression frameworks, but a novel implementation of symbolic regression called Fast Function Extraction (FFX) [4] uses regularized linear regression with pathwise learning to provide a scalable and deterministic symbolic regression framework. We utilize the FFX framework as a basis for an iterative multi-task feature learning approach. Each task ist learned separately using FFX, the selected features of the resulting task models are then weighted according to their frequency of ocurrence over all tasks. These weights are then used in the next iteration to promote features which are of importance for most of the tasks. Thus with each iteration, information from all tasks is used to consolidate the task models until the weights do not change anymore.

Our experimental results on both real world and synthetic datasets show, that our resulting task models have higher similarity and lower complexity while yielding the same prediction performance when compared to a single symbolic regression run.

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Sparse Signal Processing Technique in Multimodal Dispersive SHM

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Abstract

One of the main challenges in developing structural health monitoring algorithms is the multimodal and dispersive nature of wave propagation.

Structural health monitoring makes use of the wave propagation information in order to determine the distance between the measuring equipment and the defect from the reflected signals caused by the defect. The geometrical information from different sensor locations is then used to determine the spatial position of the defect.

The inverse problem approach makes use of the knowledge of the whole mapping between the defect and the reflections. This mapping, also called forward operator, combines the wave propagation and the geometrical information in a natural way. Once the forward mapping is known, a regularization approach can be applied in order to reconstruct the defect out of the reflections in a stable way. The main aim of this paper is to find a formulation of the forward model for an isotropic multimodal dispersive medium, which contains all important features of wave propagation, but is simple enough in order to be used in a regularization approach.

As the defects are typically small in size compared to the whole medium, our solution is assumed to be sparse in mathematical sense. In this case, sparse regularization approach is the most appropriate one to solve the inverse problem. We illustrate the application of the proposed method for defect detection by means of Lamb waves.

Detecting broken reciprocating compressor valves in the pV diagram

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Reciprocating compressors are heavily used in modern industry, for instance for gas transportation and storage. In many cases, compressors run at high capacity and without backup, hence unexpected shutdowns lead to large losses in productivity. Furthermore, there is an economic trend towards saving labor costs by reducing the frequency of on-site inspection. Such considerations mean that compressors are run by remote control stations and monitored by automated technical systems. In this case, the systems must be able to retrieve and evaluate relevant information automatically to detect faulty behaviour.

When a valve of a compressor breaks, there is a leakage and gas can flow through the closed valve. Of course, this affects the shape of the pV diagram of a compression cycle significantly. The pV diagram is used to describe corresponding changes in volume and pressure in a system. As the load control affects mainly the compression phase of a compression cycle, we concentrate on the evaluation of the expansion phase. This leads to a load independent method.

In the case of a broken discharge valve, the pressure in the cylinder decreases slower during expansion than in the faultless case. The reason for that is that gas flows through the closed valve from the discharge chamber into the cylinder. In the case of a broken suction valve, gas flows through the suction valve from the cylinder into the suction chamber resulting in a faster decreasing cylinder pressure. To quantify this difference, we linearize the pV diagram by switching to logarithmic scales. Then we can easily use the gradient of the expansion phase as an indicator for pressure reduction velocity in the compression cylinder during expansion (Figure 1). Since the pressure reduction velocity is also affected by the pressure conditions (suction and discharge pressures) we have to consider the pressure conditions in the feature space, too (Figure 2). But even faultless valves are not 100% leak tight. Depending on the valve type (design and material), they have different leakage factors. This is reflected in an offset in the feature space. The features can be classified using SVM classification. We validated the proposed method with real world data from a reciprocating compressor test bench. Compared with other feature extraction methods proposed in literature (F. Wang, L. Song, L. Zhan and H. Li, 2010, "Fault diagnosis for reciprocating air compressor valve using p-V indicator diagram and SVM"), our features show higher validation accuracy, especially in the case of small faults.

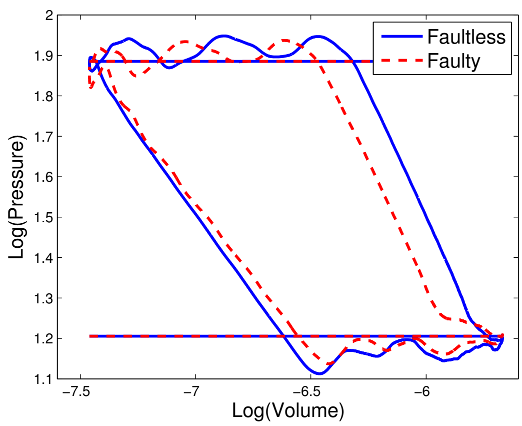

Figure 1. Logarithmic pV diagrams of measurements from faultless and faulty valves

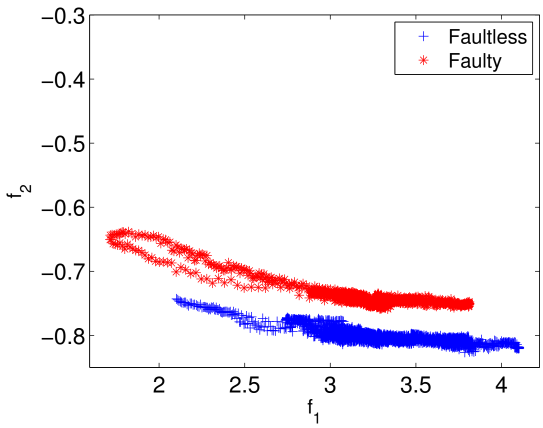

Figure 2. Features extracted from the logarithmic pV diagrams

Customized error clustering of industrial surface inspection images

Problem definition and first experiments

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Abstract

In industrial quality control in many cases the optical surface inspection of the produced items plays an important role. Our aim is to support such an industrial project with a method that helps to automate the surface inspection process.

The main task is to analyse the dataset of images that contain error-regions. Due to the errors and special properties of the construction of these images, the error-regions in most cases are not connected any more. Thus, it is necessary to find suitable clustering method to group them again into meaningful areas, mimic the human decision. Therefore we experiment with several available clustering methods, observe the possibilities of improvement.

Since there is no ground truth provided by the industrial partner, it is needed to be constructed in order to evaluate the results of clustering methods. We also observe the possibilities of evaluation, analyse different similarity measures and choose the one that is the most appropriate for our goal.

On the Performance of Master-Slave Parallelization Methods for Multi-Objective Evolutionary Algorithms ⋆

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Abstract

This paper is focused on a comparative analysis of the performance of two master-slave parallelization methods, the basic *generational* scheme and the *steady-state asynchronous* scheme. Both can be used to improve the convergence speed of multi-objective evolutionary algorithms (MOEAs) that rely on time-intensive fitness evaluation functions. The importance of this work stems from the fact that a correct choice for one or the other parallelization method can lead to considerable speed improvements with regards to the overall duration of the optimization.

Our main aim is to provide practitioners of MOEAs with a simple but effective method of deciding which master-slave parallelization option is better when dealing with a time-constrained optimization process.

In order to achieve this, we performed a comparative quantitative and qualitative analysis of the behavior of these two methods when applying them to parallelize optimization runs of two well known MOEAs: NSGA-II and SPEA2. The results indicate that 1) *the parallelization ratio* and especially 2) *the level of variance in the time-wise distribution of the fitness evaluation function* are the key factors that influence the relative performance of the two parallelization methods. The presence of variance is very important, as a rather heterogeneous fitness function can make the steady state asynchronous parallelization method (SSA-MSPS) considerably outperform its generational counterpart (GEN-MSPS).

Keywords: evolutionary computation, multi-objective optimization, performance comparison, master-slave parallelization, steady-state evolution

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