

1. Raziskovalna organizacija (*Research organisation*):

Univerza v Ljubljani, *Fakulteta za strojništvo*

2. Ime in priimek mentorja (*Name and surname of a mentor*):

Jurij Prezelj

3. Področje znanosti iz šifranta ARRS (*Primary research field*):

Veda;	Tehniške vede in Naravoslovno-matematične vede
Področje;	Energetika in Varstvo okolja
Podpodročje;	Energetski postroji
Koda;	2.03.04 1.08.00

4. Kontaktni e-naslov mentorja (*Contact of a mentor*):

Jurij.prezelj@fs.uni-lj.si

5. Kratek opis programa usposabljanja (*Short description of the program*):

IZHODIŠČE

S tehnološkim razvojem družbe se neprestano povečuje število strojev in naprav v delovnem, bivalnem in življenjskem okolju. S tem se neizbežno povečuje tudi hrup, ki ima dve nasprotujoči lastnosti. Po eni strani je moteč in negativno vpliva na ljudi, njihovo storilnost, počutje, in celo zdravje. Po drugi strani pa hrup predstavlja vir informacij, ki so v mnogih primerih nujne za nadzor delovanja strojev in naprav, za nadzor različnih procesov, za zagotavljanje varnosti in podobno. Zato so raziskave s področja zmanjševanja hrupa, ob sočasnem pridobivanju informacij iz signalov generiranega hrupa, nujne za razvoj izdelkov in dviga ravni družbe, kar je razvidno iz skokovitega povečevanja števila znanstvenih publikacij iz teh področij v zadnjih letih. Na teh področjih ima Laboratorij za Energetske Delovne stroje in Tehnično Akustiko tudi največ znanja in izkušenj, kar se odraža v znanstvenih objavah, v znanstveno-raziskovalnem sodelovanju s kolegi iz mednarodnega prostora, v sodelovanju z industrijo, v objavi monografij in s podeljenimi patenti. Predvsem pa je laboratorij opremljen z najnovejšo merilno opremo kjer gre izpostaviti akustično kamero, sistem za testiranje glušnikov in gluho sobo. Omeniti velja tudi, da je mentorjev predhodni doktorand takoj po zaključenem doktoratu ustanovil podjetje, ki uspešno deluje na področju razvoja računalniških sistemov za meritve hrupa.

OŽJE PODROČJE RAZISKOVALNEGA DELA

Stroji in naprave so praviloma sestavljeni iz večjega števila elementov, na katerih lahko identificiramo elementarne vire hrupa. Za uspešno načrtovanje tišjih izdelkov in protihrupnih ukrepov je nujno prepoznati tiste elementarne vire, ki dominirajo v skupni ravni hrupa. Za ta namen se uporablja akustična kamera. Algoritmi, ki omogočajo izdelavo akustične slike, se intenzivno razvijajo. Uporaba teh algoritmov za namen pridobivanja informacij o delovanju strojev in naprav oziroma procesov pa v nam dostopni literaturi ni pogosto obravnavana, kljub obetavnim rezultatom. Kandidat za mladega raziskovalca/raziskovalko (MR) bo zato raziskal možnosti uporabe različnih algoritmov akustične kamere za pridobivanje vhodnih podatkov, ki jih bo analiziral z različnimi klasifikacijskimi algoritmi z namenom avtomatizacije nadzora strojev, naprav in procesov. Rezultati dela MR bodo ključnega pomena pri razvoju univerzalnih sistemov za avtomatsko prepoznavo hrupnih dogodkov, hrupa strojev, napak pri njihovem delovanju, za nadzor procesov v realnem času, za kontrolo kvalitete izdelkov na proizvodni liniji in podobno.

METODE DELA

Kandidat za mladega raziskovalca/raziskovalko (MR) se bo priključil delu na raziskovalnem programu P2-0354 "Zmanjševanje hrupa in njegovega vpliva na ljudi", ki je povezan z raziskovalnim programom P2-0167 "Energetsko strojništvo". Študij MR bo potekal po doktorskem programu za strojništvo, na študijski smeri za energetske, procesne in okoljske inženirske znanosti, ki poteka na Fakulteti za strojništvo, Univerze v Ljubljani.

MR bo pridobil poglobljena znanja akustike in merilnih metod v akustiki. Posvetil se bo modeliranju kompleksnih virov hrupa, modeliranju širjenja zvočnega valovanja v prostoru in mehanizmu dušenja zvoka. Za akustično modeliranje bo uporabljal metode končnih elementov, robne pogoje pa bo določal na osnovi meritev. Pridobil bo tudi poglobljeno znanje iz digitalne obdelave akustičnih signalov, ki je potrebno za razvoj in izdelavo akustične kamere oziroma akustičnega radarja. Ta znanja bo nadgradil z analizo značilik akustičnih signalov med katere bo kot prvi vključil tudi prostorsko-časovno-frekvenčne značilke virov hrupa, ki jih bo izluščil iz rezultatov pridobljenih s pomočjo akustične kamere. Te značilke bo uporabil za klasifikacijo hrupnih dogodkov z uporabo različnih algoritmov. Primerjal bo metodo nevronskih mrež, Gaussovih mešanic in genetskih algoritmov s klasičnim k-NN algoritmom, za namen univerzalne klasifikacije hrupnih dogodkov.

MR bo aktiven pri prijavi novih EU projektov in pri organizaciji mednarodne konference. V času svojega usposabljanja bo imel priložnost sodelovati z vodilnimi strokovnjaki s področja tehnične akustike doma in v svetu. To bo po eni strani pripomoglo k temu, da bo njegovo raziskovalno delo postalo kvalitetnejše in prodornejše, po drugi strani pa bo to tudi zagotovilo, da bo njegovo raziskovanje v samem jedru trenutnih trendov na področju tehnične akustike.

CILJI IN PREDVIDENI REZULTATI

Najpomembnejši rezultat raziskovalnega dela bodo ustrezno dokumentirani originalni prispevki k znanosti. Cilj projekta je zastavljen v smeri ustvarjanja uporabnega znanja z dodano vrednostjo in možnostjo prenosa v industrijo. Predlagani raziskovalni program je skladen z usmeritvijo programske skupine z nazivom "Zmanjševanje hrupa in njegovega vpliva na ljudi".

STARTING POINT

As the technological development of the society is constantly increasing, so is the number of machines and equipment constantly increasing in the working and living environment. This inevitably increases noise, which has two contradictory properties. On one hand, it is annoying and has a negative impact on people and their productivity, well-being, and even health. On the other hand, noise is a source of information, which can be used to control the operation of machinery and equipment, to monitor various processes, to ensure safety, etc... A research in the field of noise control in combination with a research on how to obtain information from audible noise is essential for further development of products and machinery, and for further improvement of the wellbeing in the society. Importance of these topics can also be observed in the raising number of scientific publications covering these research areas in recent years. Laboratory for Pumps, Compressors and Technical Acoustics has the knowledge and experience on these topics, which is reflected in scientific publications, in scientific-research collaboration with colleagues from the international space, in cooperation with industry, in the publication of books and granted patents. Above all, the laboratory is equipped with the latest measuring equipment. Availability of the acoustic camera in the anechoic chamber of the laboratory should be emphasized. It is also noteworthy to mention that former young researcher and PhD student founded a company after finishing his studies, to successfully develop and market computer systems for environmental noise measurements.

SCOPE OF THE RESEARCH WORK

Machines and devices are typically composed from a number of components to which we can attribute elementary noise sources. For a successful design of quieter products and for successful planning of noise control measures it is necessary to identify elementary noise sources which are dominant in the overall noise level. Acoustic camera recently gained the lead role for this purpose. Algorithms for the calculation of acoustic images are being constantly developed. The application of these algorithms for the purpose of obtaining information about the functioning of the machinery and equipment or processes is not often addressed in the literature, despite promising results. A candidate for the young researcher (YR) will therefore explore the possibility of using different algorithms of acoustic camera, to obtain necessary information for the classification of noise events. Characteristics of noise events, obtained with beamforming algorithms, will be tested and used in

combination with a variety of different classification algorithms, for the purpose of monitoring the machines, devices and processes. The results of the research work will be of vital importance for further development of an universal system for automatic real time identification of noise events, fault identification on machinery and performance monitoring. System will be used for quality control of products on the production line, etc...

WORKING METHODS

A candidate for the young researcher (YR) will work in the research program, P2-0354 "Noise control and its effect on people", which is associated with the research program, P2-0167 "Power Engineering". The study of YR will be held according to the doctoral program of mechanical engineering, the study of energy, process and environmental engineering science, which takes place at the Faculty of mechanical engineering, University of Ljubljana.

YR will gain in-depth knowledge of acoustics and measuring methods in acoustics. Learning process will be focused on the numerical modelling of the complex noise sources, on the modelling of sound waves propagation within complex spaces and on the mechanisms sound absorption. Finite element method will be extensively used. Boundary conditions will be defined from measurements. YR will also gain in-depth knowledge of digital processing of acoustic signals, which is necessary for the research and development of beamforming algorithms used in the acoustic camera or in acoustic radar. YR will develop time-spatial-frequency properties of acoustic signals generated by noise sources. These properties can only be obtained with microphone array and beamforming algorithms. Application of time-spatial-frequency properties for the classification of noise events using different algorithms is a novelty in the research field. Artificial Neural Network, Gaussian mixture model and genetic algorithms will be compared with the k-NN algorithm for the purpose of a universal classification of noise events and noise source classification.

YR will be also active in the applications of new EU projects and in the organization of international conference. During the training he will have the possibility to work with leading experts in the field of technical acoustics throughout the Europe. This will contribute to the recognizably and quality of his work on one hand, and on the other hand, this will also ensure that his research will be into the very core of the current trends in the field of technical acoustics.

THE OBJECTIVES AND PLANNED RESULTS

The most important result of the research work will be documented original contribution to science in the form of papers published in the high impact journals. The goal of the project is also to set the direction of creating useful knowledge with the added value and the possibility of transfer the research into industry. The proposed research program is consistent with the research program group "Noise control and its effect on people".