

# **5th IFAC Workshop on Mining, Mineral and Metal Processing (MMM 2018)**

IFAC PapersOnline Volume 51, Issue 21

Shanghai, China  
23 – 25 August 2018

**Editor:**

**Chunhua Yang**

ISBN: 978-1-5108-7291-2

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2018) by IFAC (International Federation of Automatic Control)  
All rights reserved.

Printed by Curran Associates, Inc. (2018)

For permission requests, please contact the publisher, Elsevier Limited  
at the address below.

Elsevier Limited  
360 Park Ave South  
New York, NY 10010

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

<b>ENSEMBLE RANDOM WEIGHTS NEURAL NETWORK BASED ONLINE PREDICTION MODEL OF THE PRODUCTION RATE FOR MINERAL BENEFICIATION PROCESS</b> .....	1
<i>Jun Lu, Chuanbao Li, Jinliang Ding</i>	
<b>A CAUSAL MODEL-BASED SCHEDULING APPROACH FOR COKE OVEN GAS SYSTEM IN STEEL INDUSTRY</b> .....	7
<i>Feng Jin, Zheng Lv, Maohua Li, Lei Mou, J. Zhao, Wei Wang</i>	
<b>KNOWLEDGE MODELING FOR ROOT CAUSE ANALYSIS OF COMPLEX SYSTEMS BASED ON DYNAMIC FUZZY COGNITIVE MAPS</b> .....	13
<i>Weichao Yue, Xiaofang Chen, Keke Huang, Zhaohui Zeng, Yongfang Xie</i>	
<b>PROCESS MODELLING AND UNIVARIATE ANALYSIS OF COMMINUTION CIRCUITS</b> .....	19
<i>T. Song, T. H. Yang, J. W. Zhou, Q. K. Wang</i>	
<b>OPTIMAL CONTROL OF A ROUGHER FLOTATION CELL USING ADAPTIVE DYNAMIC PROGRAMMING</b> .....	24
<i>B. Sun, J. D. Le Roux, S. L. Jämsä-Jounela, I. K. Craig</i>	
<b>STACKING APPROACH FOR SOFT SENSOR DESIGN IN STEAM ASSISTED GRAVITY DRAINAGE APPLICATIONS</b> .....	30
<i>Chaoqun Li, Nabil Magbool Jan, Biao Huang</i>	
<b>STATE AND PARAMETER ESTIMATION IN HALL-HÉROULT CELLS USING ITERATED EXTENDED KALMAN FILTER</b> .....	36
<i>Yuchen Yao, Jie Bao</i>	
<b>PREDICTION OF COMPONENT CONTENT IN RARE EARTH EXTRACTION PROCESS BASED ON ESNS-ADABOOST</b> .....	42
<i>Yang Hui, Liu Shuli, Lu Rongxiu, Zhu Jianyong</i>	
<b>SOFT-SENSING METHOD OF COHESIVE ZONE SHAPE AND POSITION IN BLAST FURNACE SHAFT</b> .....	48
<i>Ping Zhou, Jia-Ling Li, Qi-Quan Wen, En-Xue Zu, Wei-hua Gui, Chem Q Zhou</i>	
<b>MILL LOAD PARAMETER FORECASTING BASED ON MULTI-SOURCE SINGLE-SCALE MECHANICAL FREQUENCY SPECTRAL MULTIPLE FEATURE SUBSETS</b> .....	53
<i>J. Tang, J. F. Qiao, Z. Liu, Z. X. J. Zhou, G. Yu, J. J. Zhao</i>	
<b>APPLICATION OF THE IMPROVED THE ELM ALGORITHM FOR PREDICTION OF BLAST FURNACE GAS UTILIZATION RATE</b> .....	59
<i>Yufei Ji, Sen Zhang, Yixin Yin, Xiaoli Su</i>	
<b>CHROMOGENIC AGENT OPTIMIZATION FOR DETECTION OF THE METAL IONS IN ZINC METALLURGY WASTEWATER</b> .....	65
<i>Shengnan Zou, Hongqiu Zhu, Yonggang Li, Junming Chen</i>	
<b>AN EFFECTIVE OPERATING PARAMETERS OPTIMIZATION METHOD FOR ELECTROWINNING PROCESS OF ZINC BASED ON KRIGING MODEL AND FINITE ELEMENT MODEL</b> .....	70
<i>Xi Li, Yonggang Li, Hongqiu Zhu, Shijun Deng</i>	
<b>REAL-TIME DETECTION OF STEEL STRIP SURFACE DEFECTS BASED ON IMPROVED YOLO DETECTION NETWORK</b> .....	76
<i>Jiangyun Li, Zhenfeng Su, Jiahui Geng, Yixin Yin</i>	
<b>AN INFRARED IMAGE-BASED COPPER ELECTROLYSIS SHORT-CIRCUIT DETECTION METHOD USING IMPROVED DOG FILTER</b> .....	82
<i>Xin Li, Yonggang Li, Hongqiu Zhu, Xiaoxu Hu</i>	
<b>A TIME-DELAY ANALYSIS METHOD FOR THE VARIABLES OF GRINDING PROCESS</b> .....	88
<i>Gang Yu, Junwu Zhou, Qingkai Wang, Jianjun Zhao</i>	
<b>ESTIMATION OF COPPER CONCENTRATE GRADE FOR COPPER FLOTATION</b> .....	94
<i>Hao Yan, Qingkai Wang, Zhiqiang Wang, Xu Wang, Feng Yu</i>	
<b>THREE-PHASES DYNAMIC MODELLING OF COLUMN FLOTATION PROCESS</b> .....	99
<i>Yahui Tian, Maryam Azhin, Xiaoli Luan, Fei Liu, Stevan Dubljevic</i>	
<b>FLOTATION MODELLING BASED ON FLOATABILITY DISTRIBUTIONS REGRESSED FROM ROUTINE DATA</b> .....	105
<i>Daniël J. Oosthuizen, Ian K. Craig</i>	
<b>ADAPTING A PHENOMENOLOGICAL MODEL OF A ROUGHER FLOTATION CIRCUIT TO INDUSTRIAL HISTORICAL OPERATING DATA BASE</b> .....	111
<i>L. Bergh, J. Yianatos, C. Acuña, K. Inostroza</i>	

<b>FAULT DIAGNOSIS FOR AN INDUSTRIAL HIGH PRESSURE LEACHING PROCESS WITH A MONITORING DASHBOARD .....</b>	<b>117</b>
<i>Adriaan Haasbroek, Johannes J. Strydom, John T. McCoy, Lidia Auret</i>	
<b>FEATURE SELECTION IN FROTH FLOTATION FOR PRODUCTION CONDITION RECOGNITION .....</b>	<b>123</b>
<i>Qi'An Wang, Miao Huang, Xiaojun Zhou</i>	
<b>EVALUATION OF FLOTATION WORKING CONDITION RECOGNITION BASED ON AN IMPROVED APRIORI ALGORITHM .....</b>	<b>129</b>
<i>Xiaoli Wang, Chen Song, Wei Xiong, Xingxiao Lv</i>	
<b>RESEARCH ON SELECTIVE FILTERING AND PCNN FOR NICKEL FOAM SURFACE DEFECT SEGMENTATION .....</b>	<b>135</b>
<i>Jianqi Li, Jiang Zhu, Fangyan Nie, Binfang Cao, Lijuan Huang</i>	
<b>VARIATIONAL AUTOENCODERS FOR MISSING DATA IMPUTATION WITH APPLICATION TO A SIMULATED MILLING CIRCUIT .....</b>	<b>141</b>
<i>John T. McCoy, Steve Kroon, Lidia Auret</i>	
<b>COMBINING ACTIVE LEARNING AND FISHER DISCRIMINANT ANALYSIS FOR THE SEMI-SUPERVISED PROCESS MONITORING .....</b>	<b>147</b>
<i>Lili Yin, Huangang Wang, Wenhui Fan, Junwu Zhou, Gang Yu</i>	
<b>USING CONVOLUTIONAL NEURAL NETWORKS TO DEVELOP STATE-OF-THE-ART FLOTATION FROTH IMAGE SENSORS .....</b>	<b>152</b>
<i>Y. Fu, C. Aldrich</i>	
<b>REMAINING USEFUL LIFE PREDICTION FOR PROTON EXCHANGE MEMBRANE FUEL CELL USING STOCHASTIC FUSION FILTERING .....</b>	<b>158</b>
<i>Yaqing Wang, Yanyan Hu, Changyin Sun</i>	
<b>MODEL AVERAGING AND FEEDFORWARD TEMPERATURE CONTROL IN AN OSCILLATING ANNEALING FURNACE .....</b>	<b>163</b>
<i>L. Jadachowski, A. Steinboeck, A. Kugi</i>	
<b>OPTIMAL CONTROL OF SULPHUR FLOTATION PROCESS BASED ON MACHINE VISION .....</b>	<b>169</b>
<i>Mingfang He</i>	
<b>ENERGY OPTIMIZATION OF MINERAL PROCESSING OPERATIONS THROUGH OPTIMAL ENERGY AND INVENTORY MANAGEMENT .....</b>	<b>175</b>
<i>Daniel Sbarbaro, Ruben Pena, Luis Moran</i>	
<b>INDUSTRIAL EXPERIMENTS OF SINGLE POINT FEEDING CONTROL METHOD IN LARGE-SCALE ALUMINUM REDUCTION CELL .....</b>	<b>179</b>
<i>Hongliang Zhang, Hui Guo, Jie Li, Shuai Yang, Z. Zhou, X. Chen, Yongfang Xie</i>	
<b>MULTI-OBJECTIVE OPTIMIZATION OF STEAM SYSTEM BASED ON GPU ACCELERATION .....</b>	<b>183</b>
<i>Liang Zhao, Zhencheng Ye, Wenli Du</i>	
<b>CONTROL STRATEGY FOR A MULTIPLE HEARTH FURNACE .....</b>	<b>189</b>
<i>Fuentes J. V. Gomez, S. L. Jämsä-Jounela</i>	
<b>OPTIMAL PARAMETER IDENTIFICATION FOR A HYDRODYNAMIC ROLL GAP MODEL IN HOT STRIP ROLLING .....</b>	<b>195</b>
<i>Martin Müller, Andreas Steinboeck, Katharina Prinz, Andreas Kugi</i>	
<b>TOWARDS MINERAL BENEFICIATION PROCESS CHAIN INTENSIFICATION .....</b>	<b>201</b>
<i>Markku Ohenoja, Mika Ruusunen, Antti Koistinen, Jani Kaartinen, J. Paaso, A. Isokangas, Marko Paavola</i>	
<b>STEAM HEADER STATE-SPACE MODEL DEVELOPMENT AND VALIDATION .....</b>	<b>207</b>
<i>R. Dzedzeman, J. D. Le Roux, C. J. Muller, I. K. Craig</i>	
<b>AN ADAPTIVE TIME SERIES REPRESENTATION METHOD FOR ANODE CURRENT SIGNALS IN ALUMINIUM ELECTROLYSIS .....</b>	<b>213</b>
<i>Zhaoke Huang, Chunhua Yang, Xiaofang Chen, Zhaohui Zeng</i>	
<b>NONLINEAR TIME SERIES PREDICTION MODEL BASED ON PARTICLE SWARM OPTIMIZATION B-SPLINE NETWORK .....</b>	<b>219</b>
<i>Lingshuang Kong, Xiaolong Gong, Chuanlai Yuan, Huiqin Xiao, Jianhua Liu</i>	
<b>MULTI-INNOVATION BASED IDENTIFICATION OF OUTPUT ERROR MODEL WITH TIME DELAY UNDER LOAD DISTURBANCE .....</b>	<b>224</b>
<i>Jun Du, Shijian Dong, Tao Liu, Jun Zhao</i>	
<b>TRACE MULTI-IONS CONCENTRATION DETECTION IN ZINC SULFATE SOLUTION BASED ON A NOVEL CHARACTERISTIC WAVELENGTH SELECTION METHOD .....</b>	<b>229</b>
<i>Juan Gong, Hongqiu Zhu, Yonggang Li, Junming Chen</i>	
<b>ADAPTIVE FUZZY LOCAL TERNARY PATTERN FOR MINERAL FLOTATION FROTH IMAGE EDGE DETECTION .....</b>	<b>235</b>
<i>Kaijun Zhou, Xiancheng Zhou</i>	

<b>DISCRETE ELEMENT METHOD OF COKE ACCUMULATION: CALIBRATION OF THE CONTACT PARAMETER.....</b>	<b>241</b>
<i>E. X. Zu, P. Zhou, Z. H. Jiang</i>	
<b>A METHOD FOR IMPROVING THE ACCURACY OF INFRARED THERMOMETRY UNDER THE INFLUENCE OF DUST .....</b>	<b>246</b>
<i>Dong Pan, Zhaohui Jiang, Weihua Gui, Chunhua Yang, Y. Xie, Ke Jiang</i>	
<b>ANALYTICAL INSTRUMENTATION FOR COPPER PYROMETALLURGY: CHALLENGES AND OPPORTUNITIES.....</b>	<b>251</b>
<i>Jorge Yañez, Sergio Torres, Daniel Sbarbaro, Roberto Parra, Carlos Saavedra</i>	
<b>A LIGHT FIELD IMAGING BASED MEASURING METHOD FOR BLAST FURNACE BURDEN DISTRIBUTION.....</b>	<b>257</b>
<i>Tianxiang Xu, Zhaohui Jiang, Weihua Gui</i>	
<b>MULTISTAGE ADAPTIVE OPTIMIZATION FOR STEELMAKING AND CONTINUOUS CASTING SCHEDULING UNDER PROCESSING TIME UNCERTAINTY.....</b>	<b>262</b>
<i>Sanjula Kammmattu, Zukui Li</i>	
<b>OPTIMISED BLENDING OF A BASE METAL REFINERY FEED USING EVOLUTIONARY PROGRAMMING.....</b>	<b>268</b>
<i>J. J. Burchell, J. D. Le Roux, I. K. Craig</i>	
<b>A PH MULTIPLIER-BASED PSO METHOD FOR METAL BALANCE IN NONFERROUS METAL INDUSTRY .....</b>	<b>273</b>
<i>Minghe Ge, Linqing Wang, Zheng Lv, Jun Zhao</i>	
<b>AN OPTIMAL CONTROL STRATEGY FOR HYDROMETALLURGICAL REMOVAL PROCESS UNDER UNCERTAINTY .....</b>	<b>278</b>
<i>Bin Zhang, Yiting Liang</i>	
<b>REAGENT PREDICTIVE CONTROL USING JOINT FROTH IMAGE FEATURE FOR ANTIMONY FLOTATION PROCESS.....</b>	<b>284</b>
<i>Mingxi Ai, Yongfang Xie, Degang Xu</i>	
<b>MULTIVARIATE MOLTEN IRON QUALITY MODELING BASED ON IMPROVED INCREMENTAL RANDOM VECTOR FUNCTIONAL-LINK NETWORKS.....</b>	<b>290</b>
<i>Y. Jiang, P. Zhou, G. Yu</i>	
<b>COLOR CONSTANCY OF RARE-EARTH SOLUTION IMAGE WITH ADAPTIVE PARAMETER.....</b>	<b>295</b>
<i>Hui Yang, Xuqian Zhang, Zhixin Liu, Rongxiu Lu, C. Tan, Jianyong Zhu</i>	
<b>A FUZZY MODELING METHOD BASED ON DIRICHLET PROCESS MIXTURE MODEL FOR BLAST FURNACE GAS SYSTEM .....</b>	<b>301</b>
<i>Yan Huang, Zheng Lv, Ying Liu, Wei Wang</i>	
<b>RESEARCH ON TEMPERATURE FIELD CHANGE TREND OF THE SINTERING PROCESS FOR LITHIUM-ION BATTERY CATHODE MATERIALS.....</b>	<b>307</b>
<i>Ning Chen, Binyan Li, Weihua Gui, Shujian Xu, J. Wang, Jiayang Dai</i>	
<b>UTILIZING INDUSTRY-ORIENTED FINITE ELEMENT CODES IN THE DESIGN OF VIRTUAL STEEL MILL CONCEPT .....</b>	<b>313</b>
<i>K. Ondrejko, P. Bucek, G. Hulkó</i>	
<b>NON-FIRST-ORDER KINETICS MODELLING METHOD FOR STIBNITE FLOTATION PROCESS.....</b>	<b>317</b>
<i>Xu De-Gang, Luo Cong, Chen Yi-Wan, Xie Yong-Fang</i>	
<b>FAULT DIAGNOSIS OF CHECK VALVE BASED ON CEEMD COMPOUND SCREENING, BSE AND FCM .....</b>	<b>323</b>
<i>Zhou Chengjiang, Ma Jun, Wu Jiande</i>	
<b>ECONOMIC IMPACT OF SPARGERS DEGRADATION IN FLOTATION COLUMNS .....</b>	<b>329</b>
<i>L. Bergh, J. Yianatos, C. Acuña, C. Cantellano</i>	
<b>ON-LINE MONITORING OF A PILOT FLOTATION ROUGHER CIRCUIT BY USING PCA MODELS.....</b>	<b>335</b>
<i>L. Bergh, J. Yianatos, G. Bravo</i>	
<b>AN IMPROVED BAYESIAN NETWORK METHOD FOR FAULT DIAGNOSIS .....</b>	<b>341</b>
<i>Yalin Wang, Haibing Yang, Xiaofeng Yuan, Yue Cao</i>	
<b>DYNAMIC CCA-BASED DISTRIBUTED MONITORING FOR MULTIUNIT NON-GAUSSIAN PROCESSES.....</b>	<b>347</b>
<i>Qingchao Jiang, Xuefeng Yan</i>	
<b>Author Index</b>	