INTELLIGENT SYSTEM METHOD USING FOR MODELING COMPLEXITY OF FERET

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***ABSTRACT**: For thousands of years, people have thought about how to build intelligent machines. Since then, artificial intelligence (AI) has experienced ups and downs, which proves its success and its unrealized potential. Nowadays, you can hear news about applying machine learning algorithms to solve new problems at any time. From cancer detection and prediction to image understanding and summarization and natural language processing, AI is enhancing people's capabilities and changing our world. In this article, we present using intelligent system for modeling complexity of Feret of microstructure of robot laser hardened specimens with different parameters of robot laser cell.*

***KEYWORDS:** Modeling, complexity, Feret, microstructure, laser hardening;*

1 INTRODUCTION

Artificial intelligence [1] is an emerging engineering discipline that mainly uses innovative technologies to enable computing systems to imitate human intelligence and discover new knowledge. On the one hand, it covers many professional fields, such as machine learning, deep learning, knowledge representation/reasoning, large-scale computing systems and distributed systems, logic/constraint programming, human-computer interaction, natural language processing, big data analysis, etc. In recent years, automatic learning has become a research hotspot. In an automated way, the machine tries to learn the optimal learning strategy, thereby avoiding inefficient manual adjustments by machine learning practitioners [2]. It has been developed in multiple disciplines, such as finance, medicine, manufacturing, robotics, multimedia, telecommunications, computational linguistics, etc. Now there is a huge demand for artificial intelligence experts in the local and global job markets. On the other hand, there are major challenges for how to innovate and design solid and reliable artificial intelligence solutions, and how to properly solve the ethical and social issues related to artificial intelligence.

With the improvement of the latest emerging technology capabilities and the development of manufacturing innovation, the development prospects of robotics are undergoing rapid changes, and new development trends and application areas are also emerging. During laser hardening [3], the laser beam is aimed at the hardened part or local part, and only a small amount of heat is conducted to the component. Therefore, the component is not subject to large deformation, so that only a small amount of subsequent processing is required for the hardened workpiece or even no longer needs to be processed. As a brand-new processing method, laser processing is extremely widely used and has been successfully applied in many processing fields. In the past ten years,

The development of laser processing has been changing rapidly. In addition, the higher energy efficiency and shorter process time of laser hardening play a positive role in the application of this hardening process. So the hardened workpiece can be quickly applied to the following production process. Advances in the field of advanced manufacturing in terms of intelligence, automation and information technology have promoted the integration of robotics and laser technology. Therefore, robots and lasers, two intelligent manufacturing and advanced manufacturing tools, have become standard equipment in the manufacturing industry. The laser power controller ensures the best temperature stability of ±10°K on the surface of the workpiece. The temperature of the workpiece surface is measured with a camera and processed with a laser power controller. This can be achieved by accurately assigning temperature values within the hardening track. This satisfies the basic conditions necessary to achieve uniform hardening results under high-quality requirements. The combination of the two advanced technologies will enable the two technologies to reach their extremes and completely modernize industrial practices. Robots play an unparalleled role in advanced processing technologies such as laser cutting, laser welding, laser brazing, laser cladding, laser hardening, and laser hybrid welding [4].

In the research process of materials science, characterizing the microstructure [5] can clearly summarize the relationship between the structure and performance of the material, and then change the geometry to improve the performance of the material.

In this research is presented Intelligent system method using for modeling complexity of Feret of microstructure of robot laser hardened materials with different parameters of robot laser cell.

2 MATERIALS PREPARATION, METHODOLOGY AND STATISTICAL METHOD

The research based on using the standard tool steel labeled EN 100083 − 1. The tool steel was hardened by laser at different speeds and different powers. We use a robot laser cell RV60-40 (Reis Robotics Company), with the maximum power of the robot-laser cell is 3000 W. Output power of hardening was 1500 W. Therefore, we modified the speed parameter $v \in [2, 6]$ mm/s and the temperature parameter $T \in [800, 1300]$ °C. After process of hardening, each sample was etched and polished (IMT, Institute of Metals and Technology Ljubljana, Slovenia). Electron microscopy specifically includes transmission electron microscopy, scanning electron microscopy, and electron microprobe analysis. With the help of advanced and sophisticated display instruments and equipment, the penetrating power of electrons can be used to observe the microstructure of the material in more detail structure.

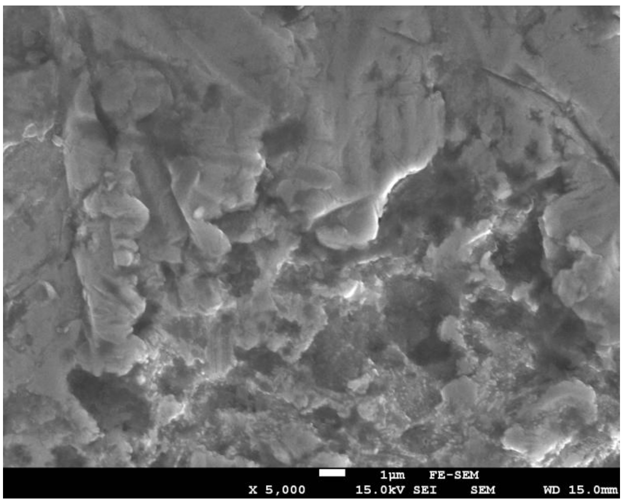


Fig. 1 Microstructure of SEM pictures of robot laser hardened specimens

ImageJ was using to analyze pictures of microstructure hardened with robot laser cell.

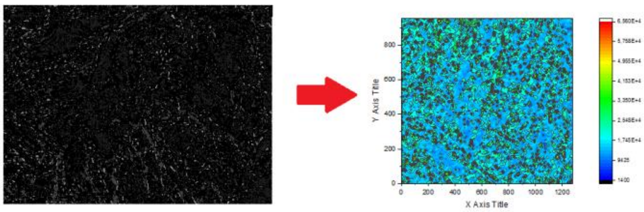


Fig. 2 Microstructure of robot laser hardened material (left), Feret from microstructure of robot laser hardened material (Right)

Firstly, number of feret were found. The longest distance between any two points along the selection boundary, also known as maximum caliper. Uses the heading Feret. So, feret have different colour. Colour represent different colour-scale of micorstructure of images. The starting coordinates of the Feret's diameter (*FeretX* and *FeretY*) are also displayed. The Draw Feret Diameter macro draws the Feret's diameter of the current selection.

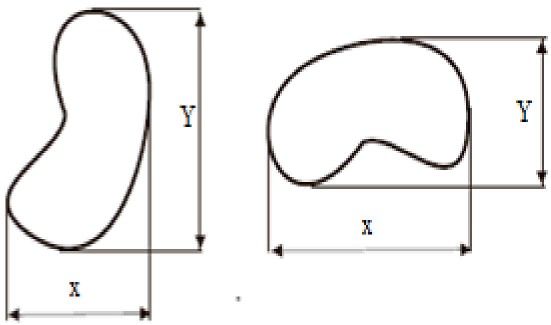


Fig. 3 Illustration of horizontal and vertical Feret diameters of a particle, Fx and Fy, respectively

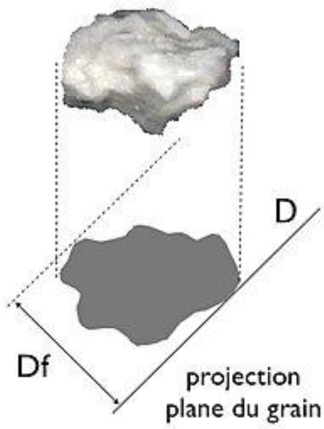


Fig. 4 Feret diameter applied to a projection of a 3D object

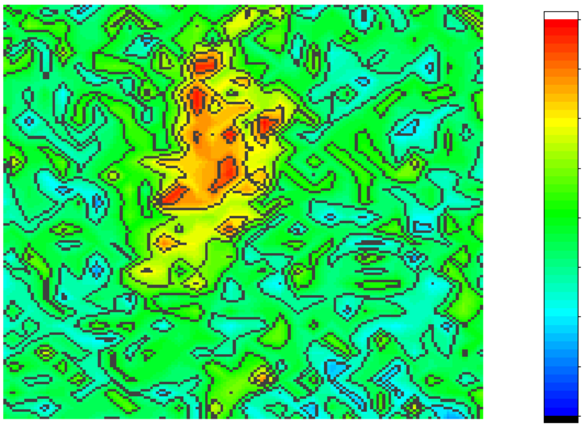


Fig. 5 Example of Feret with different diameter

To model [6] the results, intelligent system methods, namely neural network, were used.

The development of artificial neural networks (artificial neural networks) [7] originated from the artificial neuron operation model proposed by McCulloch and Pitts in 1943. After about 20 years of (initial) development, in the mid-1960s, it was difficult to break through the technology. The bottleneck remained silent for about 20 years. It was not until 1986 that McClelland and Rumelhart proposed the Back-Propagation Algorithm to break through the technical bottleneck, and it began to flourish until now. Artificial neural networks make computers more intelligent by simulating the basic operating principles and architecture of the human nervous system. Therefore, artificial neural networks are also good at areas of the human brain: speech recognition, facial (or image)) Recognition, handwriting recognition, classification, prediction, memory association and other aspects have good application results. Like the human brain, artificial neural networks have the following advantages and characteristics: (1) Self-learning ability: can learn hidden rules or patterns from a pile of input data by themselves; (2) Fault tolerance: what it learns The rules or patterns obtained are scattered and stored in the entire network, so a small part of the neural network damage will not have much impact on the system's capabilities; (3) Parallel processing capability: suitable for processing many complex Non-linear problems; (4) Self-adjustment ability: the ability to continuously adjust learned rules or patterns based on newly input data.

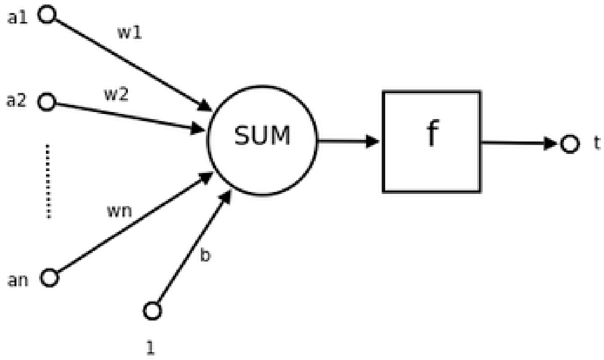


Fig. 6 Neuron schematic diagram

3 RESULTS AND DISCUSSION

In Fig 7, Feret of microstructure of robot laser hardened specimens with different parameters of robot laser cell for hardening are presented. There are 30 different pictures from microstructure of robot laser hardened specimens, hardened with different parameters of robot laser cell.

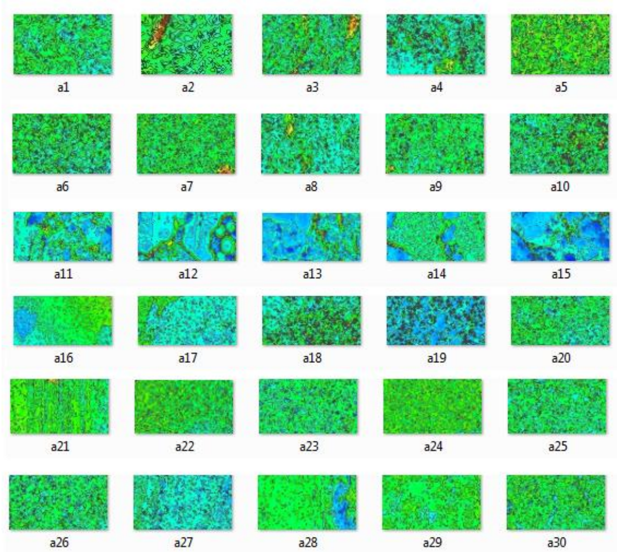


Fig. 6 Feret of microstructure of robot laser hardened specimens with different parameters of robot laser cell for hardening

In Table 1, the attributes of the hardened specimens impacting on the complexity of Feret are presented. In column S notation of specimens are presented, in column X1 temperature in °C is presented, in column X2 speed in mm/s of hardened is presented and in the last column number of feret is presented.

Table 1. Attributes of the hardened specimens

S	X1	X2	Y
P1	800	2	331
P2	900	2	325
P3	1000	2	302
P4	1100	2	317
P5	1200	2	329
P6	1300	2	336
P7	800	3	314
P8	900	3	349
P9	1000	3	337
P10	1100	3	334
P11	1200	3	305
P12	1300	3	327
P13	800	4	308
P14	900	4	326
P15	1000	4	328
P16	1100	4	338
P17	1200	4	332
P18	1300	4	352
P19	800	5	345
P20	900	5	335
P21	1000	5	358
P22	1100	5	316
P23	1200	5	347
P24	1300	5	319
P25	800	6	311
P26	900	6	330
P27	1000	6	342
P28	1100	6	354
P29	1200	6	332
P30	1300	6	339

In table 2, Statistical properties of feret of microstructure of robot laser hardened specimens are presented. In first column area of feret for each specimens are presented, in second column mean of feret for each specimens are presented, in third column standard deviation of feret for each specimens are presented, in fourth column mode of feret for each specimens are presented, in fifth column minimum z component of feret for each specimens area presented, in sixth column, in seventh column max z component of feret for each specimens are presented and in the last column number of feret are presented.

Table 1. Statistical properties of feret of microstructure of robot laser hardened specimens

S	A	M	SD	MO	MIN	MAX	MD
P1	54747	100	39	42	34	226	113
P2	54285	105	36	112	32	228	112
P3	53815	105	33	107	33	226	109
P4	53312	128	43	157	25	231	150
P5	54036	103	40	52	34	228	116
P6	56386	105	41	53	34	231	118
P7	52891	95	37	41	32	225	110
P8	55454	105	40	53	34	226	117
P9	56862	99	41	41	33	228	114
P10	55687	106	38	42	34	227	113
P11	54014	107	41	54	34	231	119
P12	53590	116	45	63	36	231	136
P13	53820	106	47	58	34	233	121
P14	54752	114	42	156	34	233	119
P15	53824	122	38	149	34	228	131
P16	54984	125	39	156	35	233	139
P17	54970	123	37	143	34	227	138
P18	55615	125	41	156	34	231	142
P19	56876	125	44	163	35	233	146
P20	56120	126	41	156	33	231	144
P21	55671	107	46	55	34	228	123
P22	53586	105	42	52	34	230	119
P23	54960	111	46	56	33	229	130
P24	53788	97	40	41	33	227	113
P25	54740	100	44	53	32	230	116
P26	54264	100	44	41	32	227	114
P27	56144	113	47	55	33	229	136
P28	55692	101	45	52	33	255	117
P29	55216	104	43	52	33	255	118
P30	57340	107	42	53	27	228	119

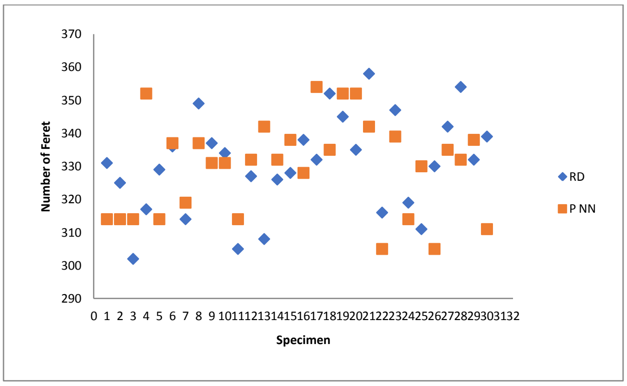
In table 3, calculated and predicted data for feret are presented. In column S notation of specimens are presented. In second column, real data are presented and in the last column predicted data with neural network are presented. In neural networks two sets of data used: the training set and the test set. The training set is the set of examples that are used to train the neural network. The test set is a "control" which allows the user to observe how the network can generalize the training set to other data.

In neural network backpropagation and 4 layer neural network was used. Speed of learning was 0.6, inertial coefficient was 0.5, test mass tolerance was 0.02 and tolerance of the learning set was 0.03.

Table 3. Calculated and predicted

S	RD	P NN
P1	331	314
P2	325	314
P3	302	314
P4	317	352
P5	329	314
P6	336	337
P7	314	319
P8	349	337
P9	337	331
P10	334	331
P11	305	314
P12	327	332
P13	308	342
P14	326	332
P15	328	338
P16	338	328
P17	332	354
P18	352	335
P19	345	352
P20	335	352
P21	358	342
P22	316	305
P23	347	339
P24	319	314
P25	311	330
P26	330	305
P27	342	335
P28	354	332
P29	332	338
P30	339	311

Specimen P21 has number of feret 358, which present maximum number of feret. Specimen P21 was hardened with speed 5 mm/s at 1000°C. Specimen P3 has number of feret 302, which present minimum number of feret. Specimen P3 was hardened with speed 2 mm/s at 1000°C. Specimen P7 has minimal area, 52891. Specimen P30 has maximal area, 57340. Minimal mean has specimen P7, 95 and maximal mean has P4, 128. Specimen P3 has minimal standard deviation, 33, maximal standard deviation has specimen P27, 47. Minimal mode has specimen P26, 41, maximal mode has specimen P19, 163. Specimen P4 has minimal z component 25, specimen P28 and P29 have maximal z component 255. Minimal median has specimen P3, 109, maximal median has specimen P4, 150. Graph 1 represent calculated and predicted. Prediction with neural network has 96% precision.



Graph 1 Calculated and predicted

4 CONCLUDING REMARKS

In this article, Intelligent system method using for modeling complexity of Feret of microstructure hardened with robot laser cell with different parameter is presented.

Machine learning allows users to use machine learning without professional knowledge to greatly reduce the threshold, or even zero threshold. Without the guidance of machine learning experts, users can get high-quality models under certain circumstances through machine learning, which makes the industry application of machine learning easier and feasible. Machine learning research many large-scale deep learning platforms, which also rely on recent system progress and research results, including how to use heterogeneous hardware to efficiently perform these deep learning tasks, and how to perform high-performance Parallel Computing. These make deep learning, especially the processing of very deep models possible.

From the performance indicators of laser hardening tooth surface hardness, hardened layer depth and pitting fatigue resistance, laser hardening can completely replace the conventional gear carburizing process. The laser hardening process uses common ordinary medium carbon steel instead of expensive alloy carburized steel, which effectively reduces the production cost and produces good economic benefits. Laser hardening solves the deformation problems in the conventional gear carburizing process, which not only saves the subsequent gear grinding process. In order to enable this technology to be widely used in the industry, it is used in the development of reliable industrial applications. In addition to high-power lasers, the research and development of the gear laser surface treatment expert system must be carried out. The laser treatment realizes computer automatic optimization of process parameters, computer simulation and real-time monitoring of the treatment process, and computer prediction of surface structure and performance after heat treatment. To achieve the easy operation of the gear laser hardening process, to achieve complex shapes and artificial intelligence surface treatment.

In the future research, several parameters of robot laser cell and several machine learning methods can be used.

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