

DAFTAR ISI

HALAMAN JUDUL BAHASA INDONESIA	i
HALAMAN JUDUL BAHASA INGGRIS	ii
HALAMAN PENGESAHAN	iii
PERNYATAAN BEBAS PLAGIASI	v
NASKAH SOAL TUGAS AKHIR	vi
HALAMAN PERSEMBAHAN	vii
KATA PENGANTAR	viii
DAFTAR ISI	xi
DAFTAR GAMBAR	xvii
DAFTAR TABEL	xxi
DAFTAR NOTASI DAN SINGKATAN	xxii
INTISARI	xxviii
ABSTRACT	xxix
BAB I PENDAHULUAN	1
1.1. Latar Belakang	1
1.2. Rumusan Masalah	2
1.3. Batasan Masalah	2
1.4. Tujuan Penelitian	3
BAB II TINJAUAN PUSTAKA	5
2.1. <i>3D Printed Flexible Pressure Sensor</i>	5
2.2. Struktur Origami	7
2.3. <i>Machine Learning Algorithm</i>	9
2.3.1. Active Learning	10
2.3.2. <i>Surrogate Model</i>	11
2.3.3. <i>Non-Dominated Sorting Genetic Algorithm (NSGA)</i>	14
BAB III LANDASAN TEORI	16

3.1. Prinsip Dasar Sensor Tekanan Fleksibel <i>Resistif</i>	16
3.1.1. Mekanisme Sensor Resistif	16
3.1.2. Pertimbangan Pemilihan Prinsip Resistif	18
3.2. <i>3D Printing</i>	19
3.2.1. <i>Fused Deposition Modeling</i> (FDM)	20
3.3. Struktur Origami	21
3.3.1. <i>Curved-Crease</i>	22
3.3.2. Miura	23
3.3.3. <i>Waterbomb</i>	24
3.3.4. Yoshimura	26
3.4. Pemilihan Material	27
3.4.1. Thermoplastic Poly-Urethane (TPU)	27
3.4.2. <i>Conductive Thermoplastic Poly-Urethane</i>	28
3.5. Uji Tekan Elektromekanis	29
3.6. Perhitungan Metrik Evaluasi Performa Sensor	31
3.6.1. Gauge Factor (GF)	32
3.6.2. Modulus Elastisitas (E)	33
3.6.3. <i>Repeatability</i> (RP)	34
3.6.4. Luas Permukaan (A)	36
3.7. <i>Artificial Intelligence</i>	36
3.7.1. <i>Supervised Learning</i>	37
3.7.1.1. <i>Tree Based Machine Learning</i>	38
3.7.1.2. <i>Margin-Based Machine Learning</i>	42
3.7.1.3. <i>Statistic-Based Machine Learning</i>	43
3.7.1.4. <i>Probabilistic-Based Machine Learning</i>	45
3.7.1.5. <i>Artificial Neural Network (ANN)</i>	49
3.7.2. <i>Unsupervised Learning</i>	50
3.7.3. Algoritma Optimasi	51

3.7.3.1. <i>Bayesian Optimization</i>	53
3.7.3.2. <i>Non-dominated Sorting Genetic Algorithm</i>	55
3.7.3.3. <i>Multi-Objective Particle Swarm Optimization</i>	58
3.7.3.4. <i>Reinforcement Learning</i>	60
3.8. <i>Active Learning</i>	61
3.8.1. Skenario dan Jenis Strategi Kueri (<i>Query Strategy</i>)	63
3.8.2. Implementasi <i>Active Learning</i>	65
3.8.3. Metrik Ketidakpastian dalam Strategi Kueri	66
3.8.3.1. <i>Uncertainty Sampling</i>	66
3.8.3.2. <i>Hybrid Query Strategy</i>	67
3.8.4. <i>Active Learning</i> untuk Optimasi Multi-Objektif	68
3.8.5. <i>Stopping Criterion</i>	69
3.8.5.1. Kriteria Konvensional	70
3.8.5.2. Kriteria Pemberhentian Adaptif	70
3.8.6. <i>Latin Hypercube Sampling</i>	71
3.9. <i>Algoritma Gaussian Process Regressor sebagai Surrogate Model</i>	72
3.9.1. <i>Feature Selection</i>	74
3.9.1.1. <i>Polynomial Features</i>	75
3.9.1.2. <i>Mutual Information (MI)</i>	76
3.9.2. <i>Hyperparameter Tuning</i>	77
3.9.2.1. <i>Bayesian Optimization</i> untuk <i>Hyperparameter Tuning</i>	77
3.9.2.2. <i>Automatic Relevance Determination</i>	78
3.9.3. <i>Mean Global Uncertainty Estimation (MGUE)</i>	79
3.10. <i>Algoritma Non-dominated Sorting Genetic Algorithm</i>	80
3.10.1. Stratifikasi Berbasis Kasta dan <i>Hyperparameter</i> Dinamis	81
3.11. <i>Sistem Mekatronika</i>	83
3.12. <i>Algoritma Kalibrasi Adaptif</i>	85
BAB IV METODE PENELITIAN	86

4.1. Waktu dan Tempat Penelitian	86
4.2. Diagram Alir Penelitian	87
4.3. Alat dan Bahan Penelitian	89
4.3.1. Alat	
4.3.2. Bahan	92
4.4. Parameter 3D Print	94
4.5. Prosedur Pengujian	95
4.6. Pemilihan Struktur Berdasarkan Sifat Elektromekanis	100
4.7. Pengaturan Eksperimen	102
4.7.1. Penentuan Parameter Desain yang Akan Divariasi	102
4.7.2. Perancangan Sistem iLogic Autodesk Inventor Untuk Otomatisasi <i>Design Generation</i>	105
4.7.3. Penentuan <i>Design Constraint</i>	105
4.7.4. Penentuan Objektif Optimasi	108
4.8. Logika Pemrograman	109
4.8.1. Pra-pemrosesan Data	109
4.8.1.1. Regresi	109
4.8.1.2. <i>Feature Selection</i>	112
4.8.1.3. Kalkulasi Metrik Performa Sensor	114
4.8.2. Kerangka Program <i>Active Learning</i>	116
4.8.2.1. Algoritma <i>Bayesian Optimized Gaussian Process Regressor</i> (BO-GPR)	123
4.8.2.2. Algoritma <i>Stratification Based Non-dominated Sorting Genetic</i> <i>Algorithm with Dynamic Hyperparameter</i> (SB-NSGA-DH)	127
4.8.2.3. Mode Eksplorasi	131
4.8.2.4. Mode Hibrida	136
4.8.2.5. Mode Eksploitasi	141
4.9. Pengujian Desain Akhir	144
4.10. Perakitan Pressure Mat Sensor	147

4.11. Pengujian Pressure Mat Sensor	149
BAB V HASIL DAN PEMBAHASAN	150
5.1. Analisis <i>Machine Learning</i>	150
5.1.1. Pemilihan <i>Machine Learning</i> Prediksi	150
5.1.1.1. <i>Random Forest Regression</i>	150
5.1.1.2. <i>Extreme Gradient-Boosting Machine (XGBoost)</i>	151
5.1.1.3. <i>Support Vector Regression</i>	151
5.1.1.4. <i>Linear Regression</i>	152
5.1.1.5. <i>Polynomial Regression</i>	152
5.1.1.6. <i>Gaussian Process Regression</i>	153
5.1.1.7. <i>Artificial Neural Network</i>	154
5.1.1.8. Tabel Perbandingan	155
5.1.2. Pemilihan Algoritma Optimasi	158
5.1.2.1. MOBO	158
5.1.2.2. NSGA	159
5.1.2.3. MOPSO	160
5.1.2.4. <i>Reinforcement Learning</i>	162
5.1.2.5. Tabel Perbandingan	163
5.2. Pemilihan Struktur Origami	166
5.2.1. <i>Curved-Crease</i>	167
5.2.2. Miura	169
5.2.3. <i>Waterbomb</i>	171
5.2.4. Yoshimura	173
5.2.5. Seleksi Struktur	174
5.3. Mode Eksplorasi	176
5.4. Mode Hibrida	183
5.5. Mode Eksploitasi	195
5.6. Pengujian Akhir	205

5.6.1. Analisis Sensor Terpilih	205
5.6.2. Variasi Pengujian	210
5.7. Demonstrasi <i>Pressure Mat Sensor</i>	213
5.8. Pengembangan Lebih Lanjut, Aplikasi Alternatif, Potensi Pemanfaatan Algoritma <i>Active Learning</i>	219
BAB VI KESIMPULAN DAN SARAN	224
6.1. Kesimpulan	224
6.2. Saran	225
DAFTAR PUSTAKA	228
LAMPIRAN	237