

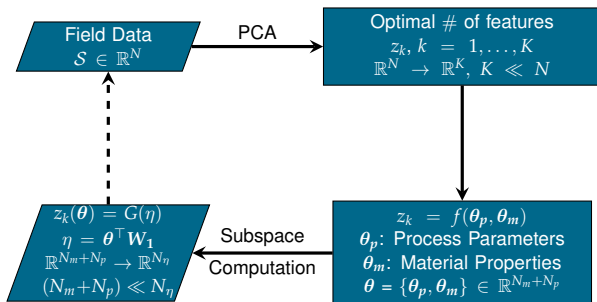
# A Fast Supervised Learning Method for High-Dimensional Problems

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# PRINCIPAL COMPONENT–ACTIVE SUBSPACE (PCAS) METHOD



$$G(\eta) \rightarrow z_k(\theta) \rightarrow \mathcal{S}$$

# FINITE ELEMENT MODEL

Heat Transfer:

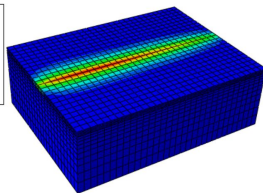
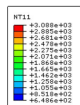
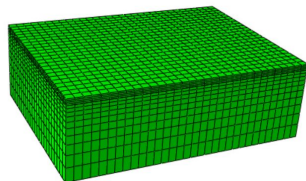
$$\rho C_p(T) = \nabla \cdot \mathbf{q}(\mathbf{r}, t) + Q(\mathbf{r}, t)$$

$$\mathbf{q} = -\kappa(T) \nabla T$$

$$Q = f(z, P) \exp(f(x, y, v))$$

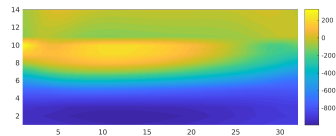
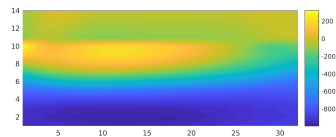
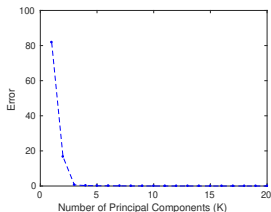
$P$ : Laser Power (W),  $v$ : Scan speed (m/s)

Stress Calculation:



# RESIDUAL STRESS FIELD

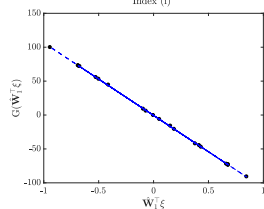
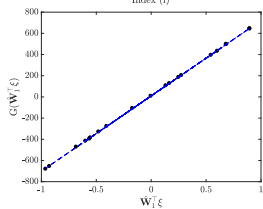
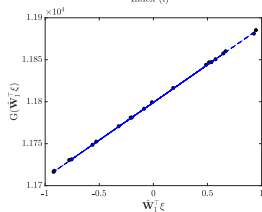
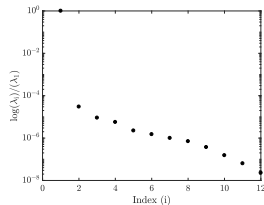
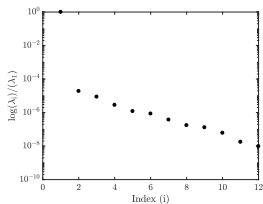
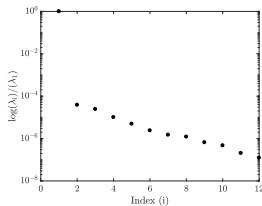
## Principal Component Analysis



$$\mathbb{R}^{32 \times 14} \rightarrow \mathbb{R}^3 (K = 3)$$

Parameter	Nominal Value
Scan Speed, $v$ (mm/s)	500
Laser Power, $P$ (W)	160
Pre-heat Temperature, $T_0$ (C)	650
Yield Strength, $Y$ (MPa)	825
Elastic Strength, $E$ (GPa)	110
Density, $\rho$ (kg/m <sup>3</sup> )	4428
Specific heat, $C_p = C_0 + C_1 T + C_2 T^2$ (J/kg/K)	540, 0.43, $-3.2 \times 10^{-5}$
Thermal Conductivity, $\kappa = D_0 + D_1 T + D_2 T^2$ (W/m/K)	7.2, 0.011, $1.4 \times 10^{-6}$

# ACTIVE SUBSPACE DISCOVERY



# GSA: ACTIVITY SCORES

$$\nu_{i,r}(f) = \sum_{j=1}^r \lambda_j w_{i,j}^2, i = 1, \dots, N_p$$

