



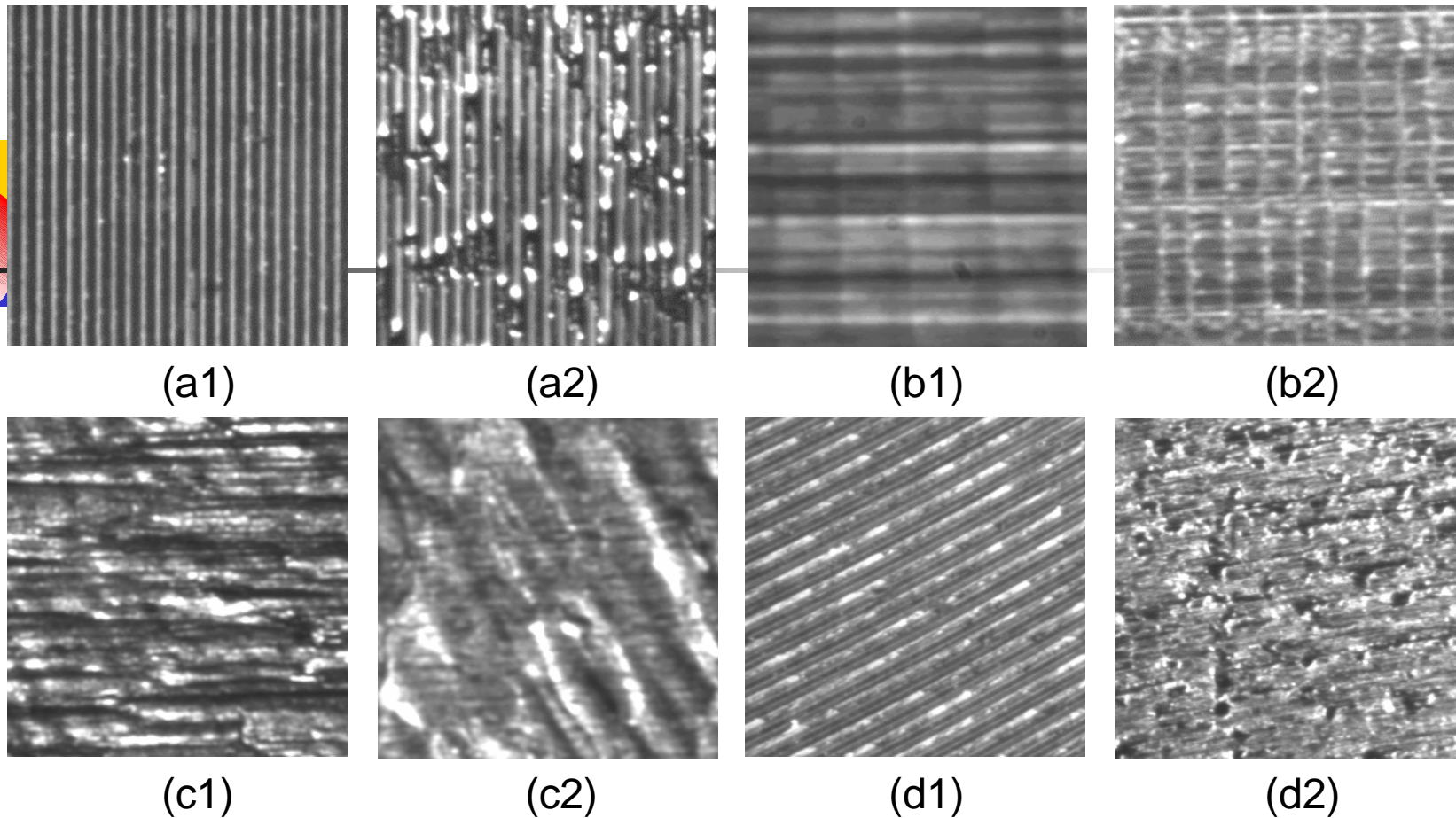
# Computer Vision based Tool Wear Monitoring techniques

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**Figure 1.** Typical surface images produced by sharp tool and dull tool respectively. (a1, a2). turning (steel); (b1, b2). end milling (aluminum); (c1, c2). end milling (steel); (d1, d2). face milling (steel).



# Our Approaches

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- Structural based texture analysis
  1. Insensitive to uneven illumination
  2. Extract geometric features (primitives)
  3. Applicable to various machining processes and conditions
  
- Fractal Analysis
  1. Fractal Dimension is closely related to the roughness of the surface.
  2. Anisotropic of machined surface should be taken into consideration.



# Decision Making Techniques

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- Minimum Distance Classifier

Differentiate surfaces produced by sharp tool and dull tool.

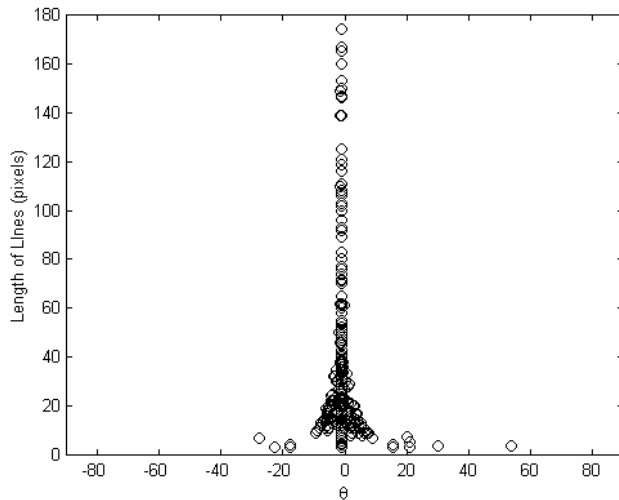
- Multi-Layer Perception

Estimate the flank tear using function approximation

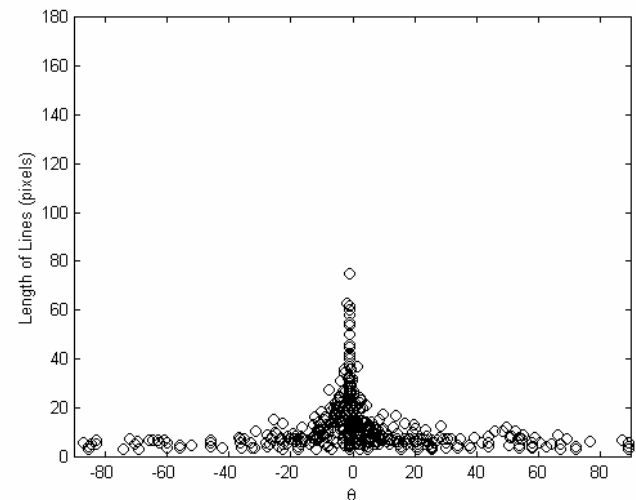
- Hidden Markov Models

Detect the inherent states in the tool wear process

# Results and Discussions



(a)



(b)

Figure 2. The distribution of length and direction of detected lines for machined surfaces produced by (a) sharp tool (b) dull tool. Each circle presents a detected line segment.

# Results and Discussions (continued)

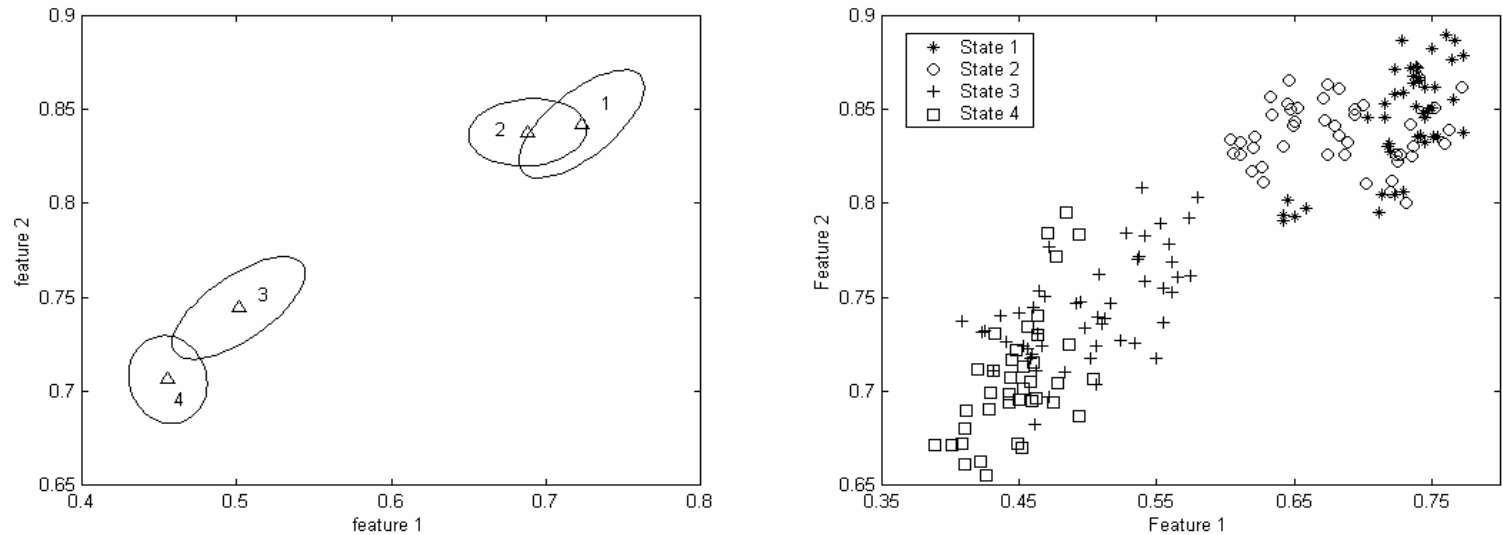


Figure 3. HMM training results and classification result.

# Results and Discussions (continued)

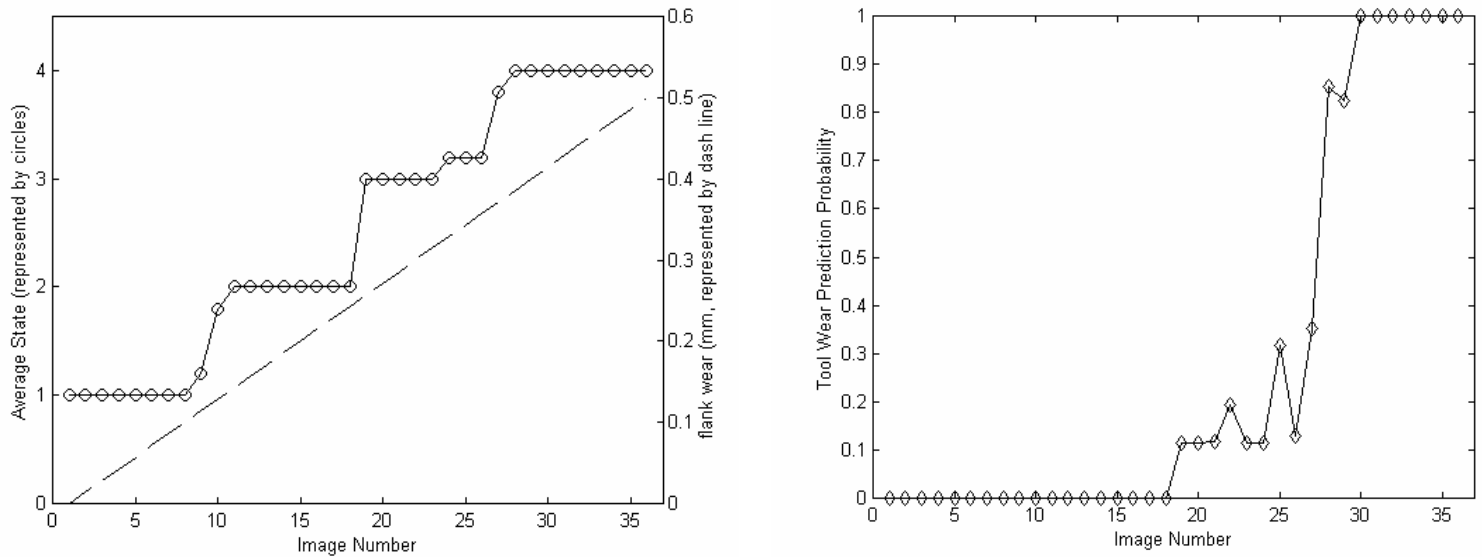


Figure 4. States detection and prediction