A Novel Model for Tool-Wear Estimation

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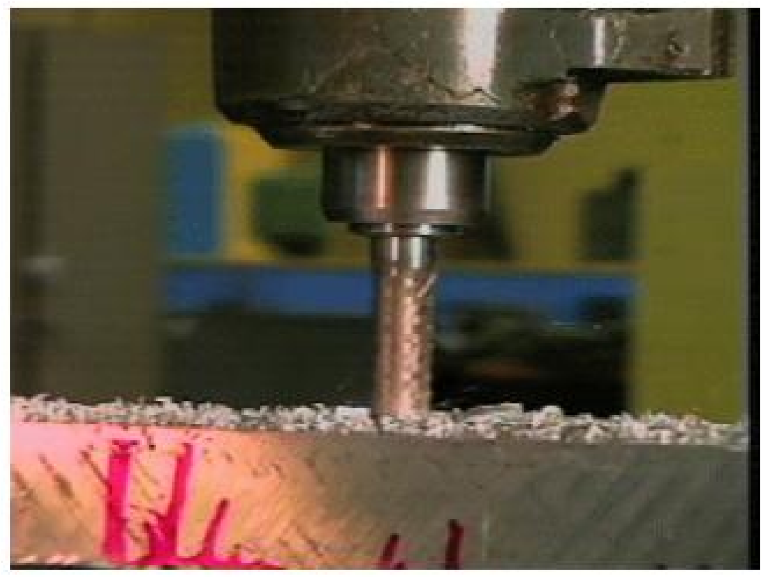
Aim: To estimate *wear* in a milling tool from information present in the *acoustic emissions* during metal cutting.

Data: Samples from accelerometer mounted on tool spindle.

Approach: Model the wear process as a *Hidden Markov Model*



Sound - is affected by *wear level*
- is an indicator of *wear rate*

Three elements:

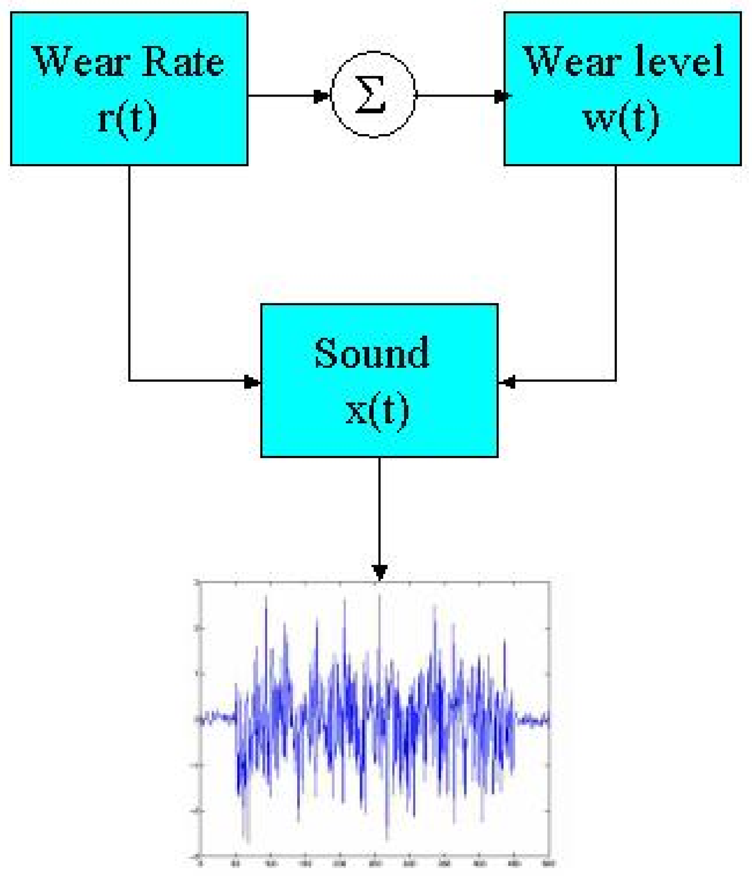
r(t) - Wear rate at time *t*, is *Markov*.

w(t) - Wear level at time *t*.

$$w(t)=w(0)+\sum_{t'=1}^{t} r(t')$$

x(t) - Feature vector derived from the sound (observations)

$$x(t) \sim P_{r(t),w(t)}(x)$$



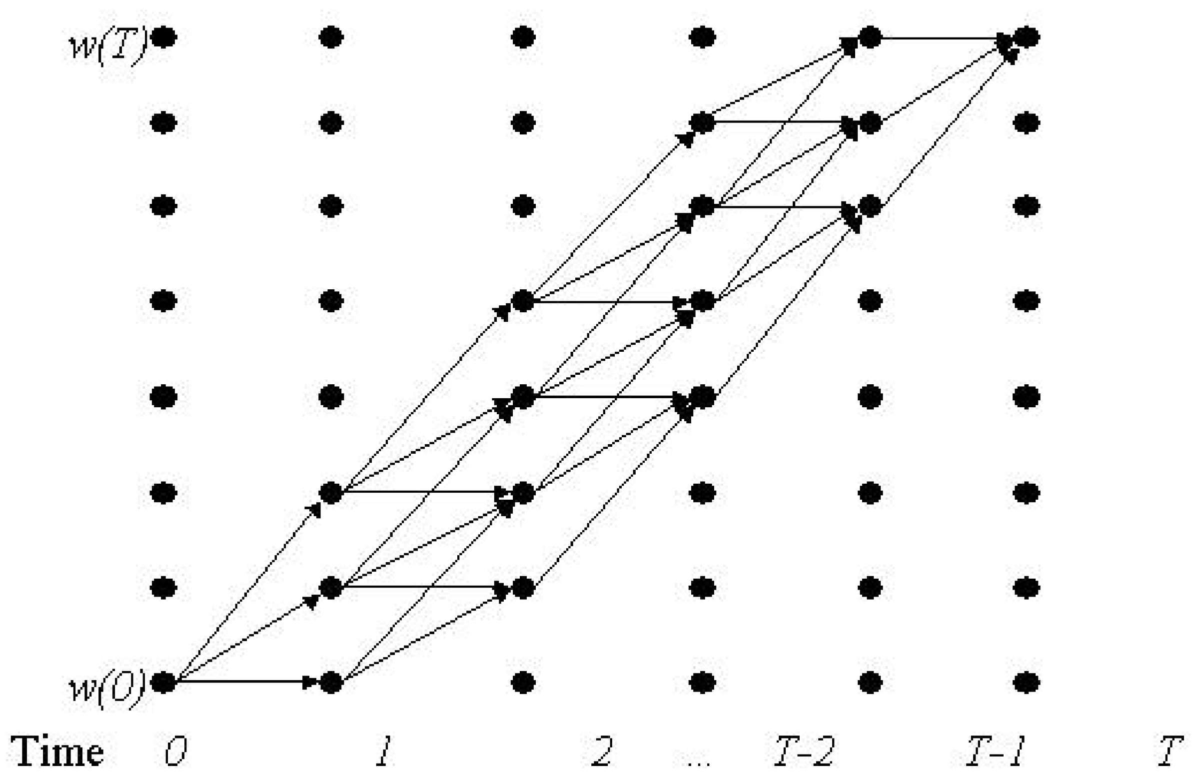
Baum-Welch Algorithm:

1) Start with a good guess for all parameters.(Transition probabilities and $P_{r(t),w(t)}(x)$)

2) Take all sequences of $r(t)$ that start from $w(0)$ and end at $w(T)$.

3) Compute expected values for parameters.

4) Iterate until convergence.



Isolating wear-rate features

1) Create classifier using only wear-level information.
2) Use classifier on training data to separate high-wear segments from low-wear segments.
3) Use Fischer discriminant to pick out features that most separate high-wear from low-wear.

Average absolute wear error in 0.001 inch

Type of classifier	Training set	Testing set
Using wear- level information only.	0.46	0.42
Using wear-level and wear-rate information	0.33	0.37

Wear-level and wear-rate estimate vs. tool life