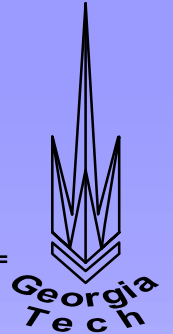


3D Metrology in Precision Manufacturing



Precision Machining Research Consortium

Industrial Advisory Board

Georgia Institute of Technology

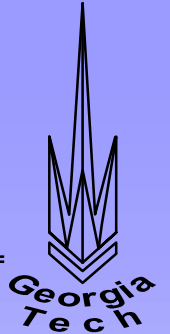
29 October 1997

Andre Claudet

Tommy Tucker

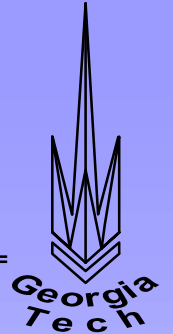
Advisor: Dr. Tom Kurfess

Measurement Is Important



- ❖ Conformance to specifications must be quantified
- ❖ Selection of measurement equipment and procedures for precision parts is not trivial
- ❖ Precision analysis of precise data is need in precision manufacturing

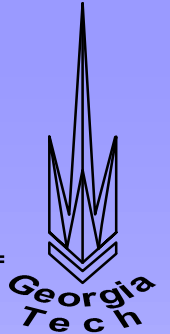
Established Inspection Methods



- ❖ Calipers and micrometers
- ❖ Shadow graphs
- ❖ Specialty gages
- ❖ Coordinate measurement machines used for 2D geometry

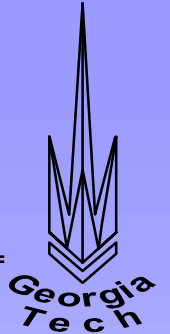


Parts Are Three Dimensional



- ❖ Manufactured parts are 3D, the measurement should be also
- ❖ Coordinate measurement machines provide three dimensional measurement data
- ❖ The challenge is in the analysis

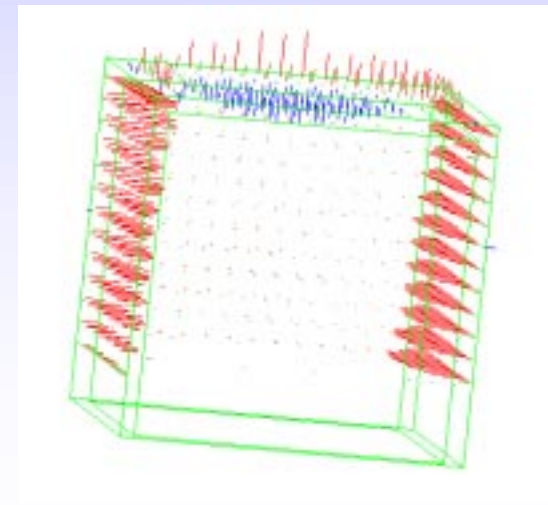
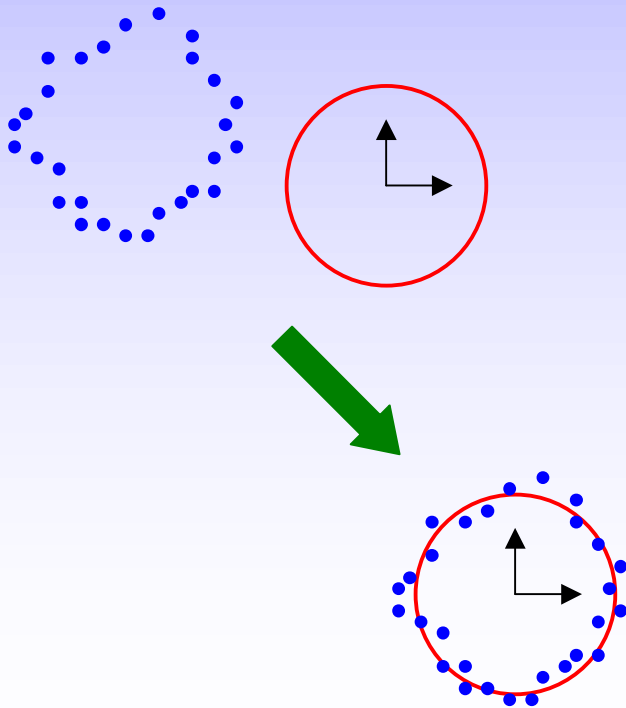
Metrology Techniques



- ❖ Data localization
- ❖ Data localization with geometric parameter estimation
- ❖ Zone fitting
- ❖ Minimum zone fitting
- ❖ Optimization for process parameters using measurement data

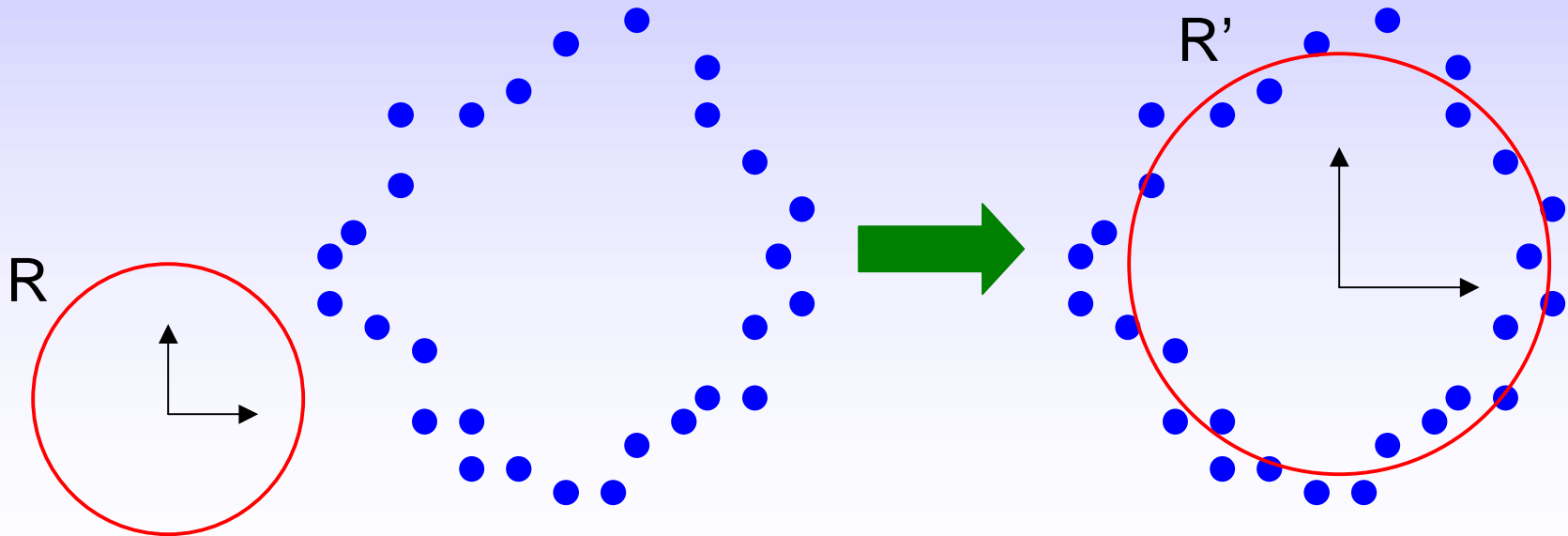
Data Localization

- ❖ Minimizes the sum of the squares of the point to surface deviations
- ❖ Transform points from measurement coordinate system to best fit position and orientation

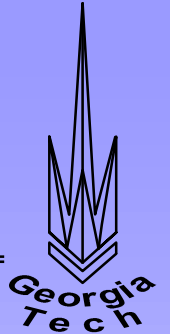


Data Localization With Geometric Parameter Estimation

- ❖ Fit model dimensions to point cloud
- ❖ Provides dimensions from three dimensional data

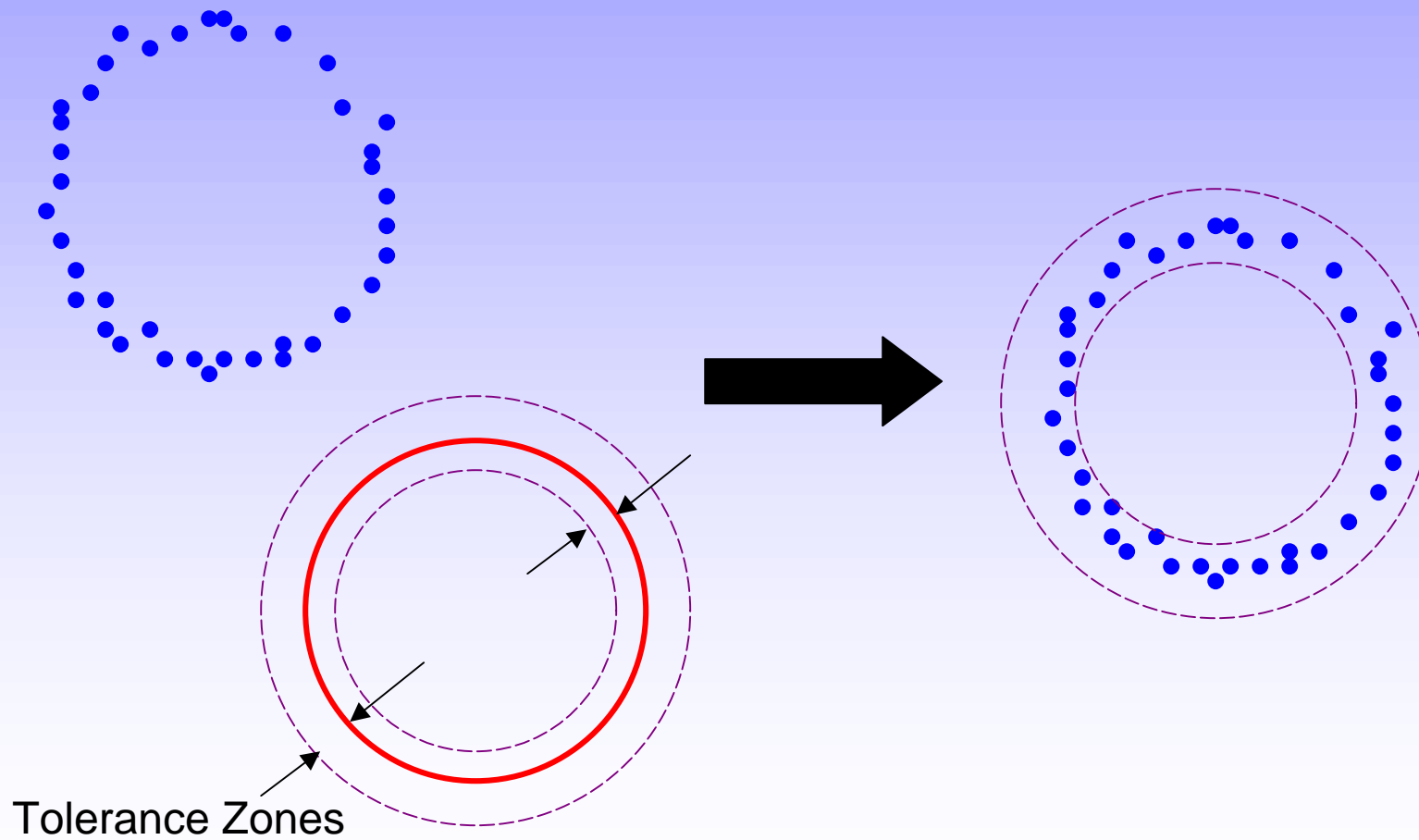


Zone Fitting



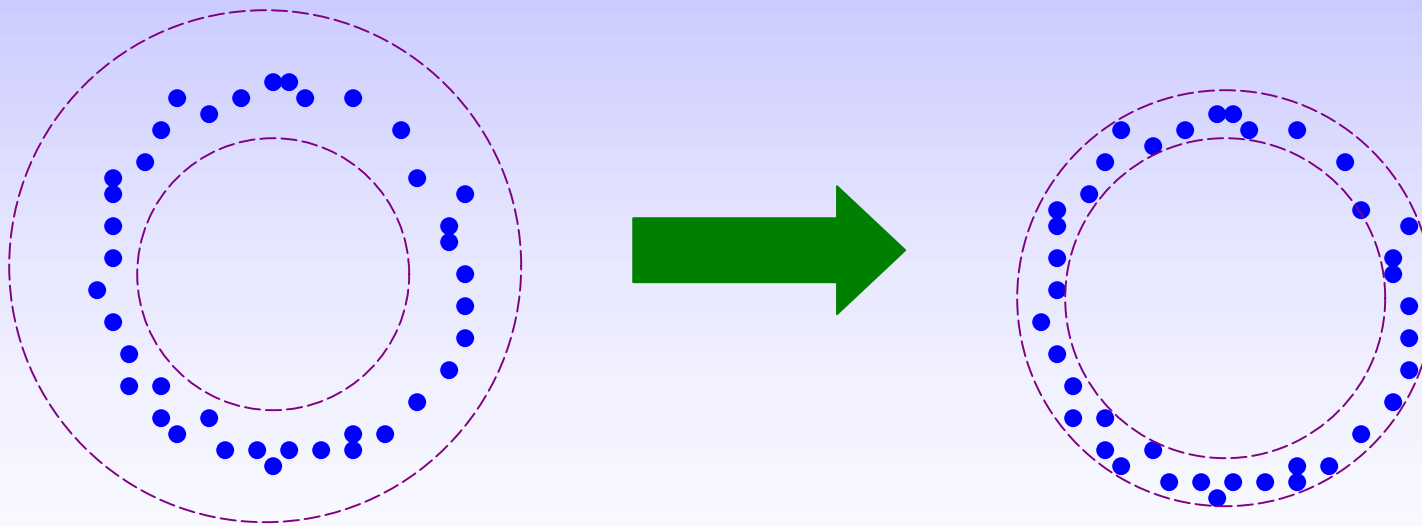
- ❖ Fit point data with in a given tolerance zone
- ❖ Minimize for points being either in or out of the zone
 - Inside zone: no penalty
 - Outside zone: ssqe penalty

Zone Fitting

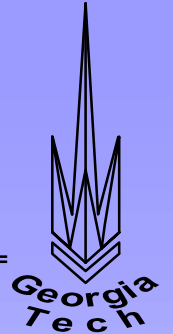


Minimum Zone Fitting

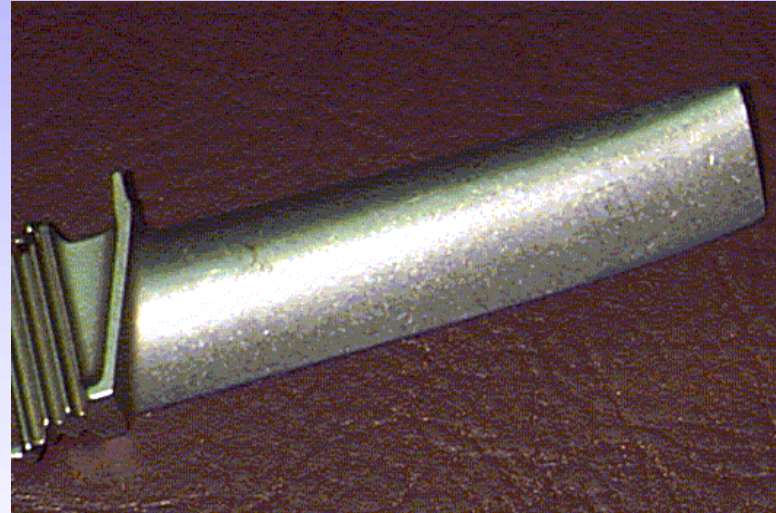
- ❖ Tolerance fit with the tolerance band include as optimization parameters



Which Approach Is Best?

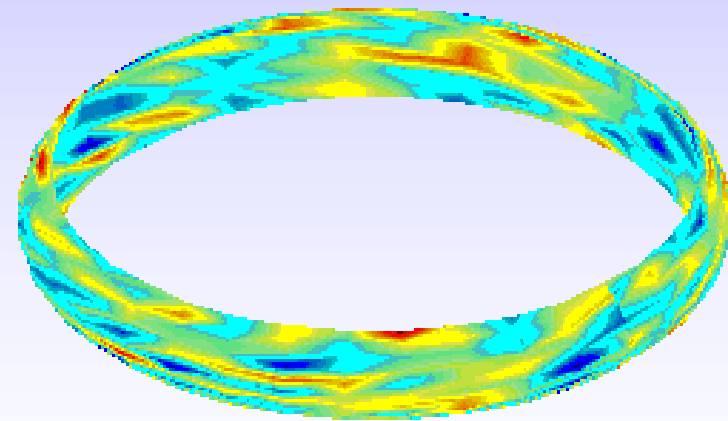
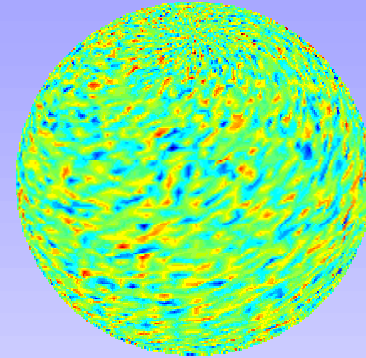


- ❖ Decide what is important for the part
- ❖ Deviations from nominal
- ❖ Pass/fail specifications
- ❖ Surface geometry estimation

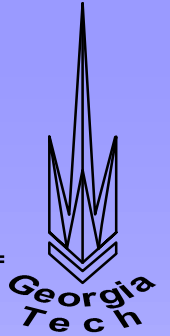


Finer Points

- ❖ Assemblies & 3D metrology
- ❖ Symmetry
- ❖ Error characterization



Future Needs



- ❖ PC based
- ❖ Robust
- ❖ Large data sets
- ❖ Fast
- ❖ Efficient