Probabilistic pipe strength and toughness estimation through information fusion with Bayesian updating

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Main Objective

This project was awarded to Arizona State University in order to develop a novel Bayesian network tool for information fusion from multimodality diagnosis results to allow for accurate prediction of probabilistic pipe strength and toughness, thereby accounting for the inhomogeneity and uncertainties in the system, not addressed with the present techniques of detection.

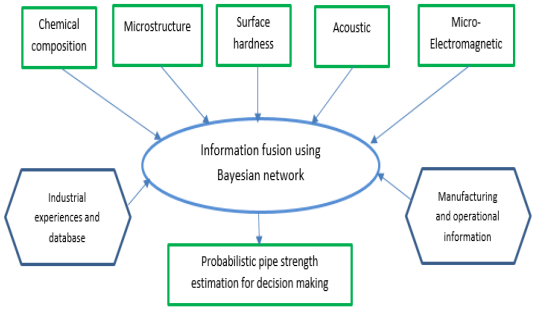


Figure 1. Schematic illustration of the proposed pipe strength estimation framework

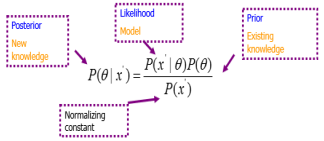


Figure 2. Bayesian Updating Principle

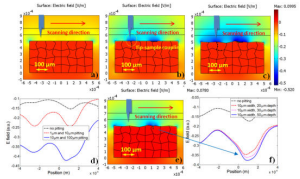


Figure 3. simulation study for near-field microwave detection of damage

Project Approach/Scope

- **Experimental investigation and data analysis of material basic properties; chemical, metallurgical, acoustic and micro-electromagnetic etc.**
- **Integration of the information from the multiple sources into a Bayesian Network fusion model.**
- **Development of microstructure sensitive NDT techniques to characterize pipe steel materials and correlate the materials strength and toughness with near-field microwave properties and EMAT/Barkhausen noise data. The system prototyping is assisted by the multi-physics modeling.**
- **Development of a microstructure-property based multiscale 3-D stochastic reconstruction model as an integrated computational framework.**

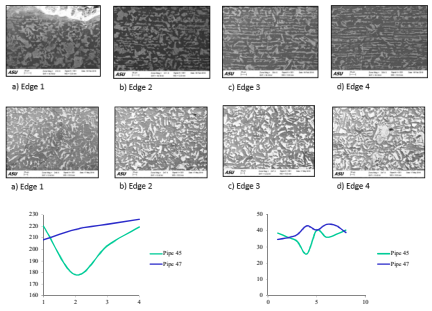
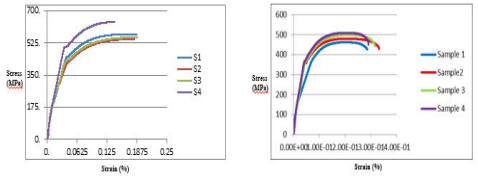


Figure 4. Through thickness evolution of microstructure, hardness and volume fraction of two pipe samples



Stress-strain plot for Pipe 45

Samples	YS (MPa)	UTS (MPa)
S1(Top Layer)	450	572.99
S2(Layer 2)	425	538.4
S3(Layer 3)	435	555.6
S4(Layer 4)	506	637.5

Stress-strain plot for Pipe 47

Samples	YS (MPa)	UTS (MPa)
S1(Top Layer)	355.5	462.2
S2(Layer 2)	358.4	479.4
S3(Layer 3)	366.2	497.8
S4(Layer 4)	371.08	508.4

Figure 5. Through thickness evolution of mechanical properties for the two pipe samples

Expected Results or Results to Date

- **A fast SNMMI system using novel continuous scanning method; five to ten times fast, superior imaging resolution preserved.**
- **The circuit and antenna for multi-channel scanning; portable for future field testing.**
- **Scanning images deconvolution; Improved images quality by removing the effect of the PSF.**
- **Experimental analysis conducted on two samples from GTI (Pipe grade; X50~X60), in the thickness direction.**
- **Microstructure change observed for one sample with very little change in volume fraction for both samples. Tensile and Hardness test predicted a certain trend in both samples.**
- **A Bayesian Network prediction model designed in c WINBUGS with features; reduced uncertainty , node sensitivity and possibility to update all the nodes in the system.**
- **A stochastic 3-D reconstruction model constructed for isotropic portions of one of the pipe samples**

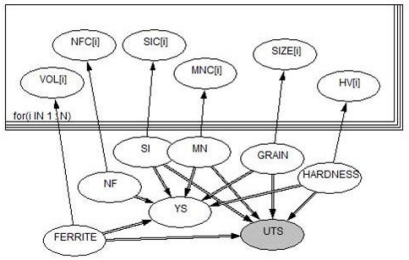


Figure 6. Bayesian Network Model for Yield Strength and Ultimate Tensile Strength determination

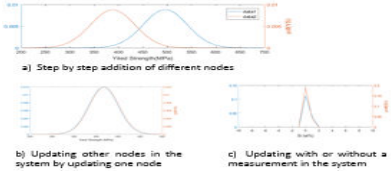


Figure 7. Updating the different nodes

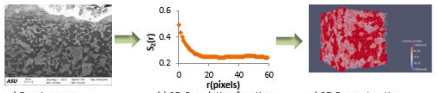


Figure 8. 3D Reconstruction of an isotropic pipe sample

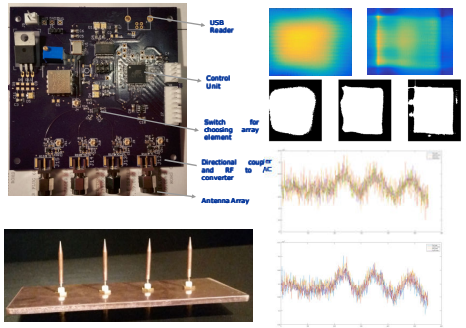


Figure 9. Improvements of the near-field scanning system

Acknowledgments

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