EPSTEIN INSTITUTE SEMINAR ISE 651

DOMAIN-INFORMED MACHINE LEARNING OF SURFACE MANIFOLD DATA AND ITS APPLICATION IN 3D PRINTING

ABSTRACT

SURFACE MANIFOLD DATA ARE WIDELY COLLECTED TO CAPTURE THE TOPOLOGICAL AND GEOMETRIC STRUCTURES OF THREE-DIMENSIONAL (3D) OBJECTS, SUCH AS MANUFACTURED PRODUCTS AND ANATOMICAL STRUCTURES. CHARACTERIZING, MODELING, AND LEARNING SURFACE MANIFOLD DATA ARE ESSENTIAL FOR FACILITATING DECISION-MAKING AND SOLVING ENGINEERING CHALLENGES IN MANUFACTURING AND HEALTHCARE. HOWEVER, SEVERAL FUNDAMENTAL CHALLENGES ARISE. FIRST, SURFACE MANIFOLD DATA ARE HIGH-DIMENSIONAL AND EXHIBIT A LARGE VARIETY OF COMPLEX GEOMETRIC STRUCTURES. SECOND, THE CHARACTERIZATION OF MANIFOLD DATA DEPENDS NOT ONLY ON GEOMETRY BUT ALSO ON PHYSICAL DOMAINS. THIRD, THE LACK OF THE APPROPRIATE DATA AND PHYSICAL KNOWLEDGE LIMITS THE APPLICABILITY OF COMMON MACHINE LEARNING APPROACHES.

TO ADDRESS THESE CHALLENGES, WE PROPOSE A DOMAIN-INFORMED SURFACE MANIFOLD DATA LEARNING METHODOLOGY. THIS TALK PRESENTS KEY ELEMENTS OF THIS METHODOLOGY: DOMAIN-INFORMED SURFACE MANIFOLD CHARACTERIZATION, DIMENSION REDUCTION, AND FEATURE EXTRACTION FOR PRODUCT QUALIFICATION IN 3D PRINTING. CURRENT QUALIFICATION METHODS ARE OFTEN LABOR-INTENSIVE, AS THEY MUST ACCOMMODATE AN INFINITE VARIETY OF DESIGN GEOMETRIES AND DOMAIN CONSTRAINTS. TO ENABLE AUTOMATED PRODUCT QUALIFICATION, WE LEVERAGE DOMAIN KNOWLEDGE OF PRODUCT GEOMETRIC QUALITY IN SURFACE MANIFOLD LEARNING. THE INFINITE DIMENSIONALITY OF PRODUCT GEOMETRIES IS REDUCED BY DEFINING FINITE SURFACE PATCH TYPES, WHICH ARE ASSOCIATED WITH VARIED PATCH DEVIATION PATTERNS. THE CHARACTERIZATION OF THESE SURFACE PATCHES IS AUTOMATED VIA THE LAPLACE-BELTRAMI (LB) OPERATOR AND CRITICAL POINTS THAT INDICATE PATCH DEVIATIONS. THESE GEOMETRIC DESCRIPTORS ALSO ENABLE AUTOMATED PATCH EXTRACTION THROUGH ACTIVE LANDMARK SELECTION FOR PATCH CENTERS AND CHANGEPOINT DETECTION FOR OPTIMAL PATCH SIZES. THIS TALK WILL ALSO BRIEFLY INTRODUCE A PROTOTYPE DIGITAL TWIN SYSTEM FOR AUTONOMOUS PRODUCT QUALIFICATION AND QUALITY CONTROL IN 3D PRINTING.

DR. WEIZHI LIN (5.2025)

ASSISTANT PROFESSOR IN INDUSTRIAL AND SYSTEMS ENGINEERING AT SAN JOSE STATE 7.2025

SPEAKER BIO

WEIZHI LIN WILL JOIN SAN JOSE STATE UNIVERSITY AS A TENURE-TRACK ASSISTANT PROFESSOR IN THE DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING. SHE RECENTLY SUCCESSFULLY DEFENDED HER PH.D. DISSERTATION IN THE DANIEL J. EPSTEIN DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING AT THE UNIVERSITY OF SOUTHERN CALIFORNIA (USC PRIOR TO HER DOCTORAL STUDIES, SHE RECEIVED A BACHELOR OF SCIENCE IN STATISTICS FROM BEIHANG UNIVERSITY IN 2019. HER RESEARCH FOCUSES ON DOMAIN-INFORMED STATISTICAL AND MACHINE LEARNING FOR HIGH-DIMENSIONAL AND COMPLEX DATA, SUCH AS SURFACE MANIFOLD DATA, BIOSENSING SIGNALS AND IMAGE DATA. HER WORK CONTRIBUTES TO THE DEVELOPMENT OF ENABLING METHODOLOGIES FOR DIGITAL TWIN SYSTEMS IN SMART MANUFACTURING AND HEALTHCARE. WEIZHI HAS RECEIVED MULTIPLE AWARDS IN RECOGNITION OF HER WORK, INCLUDING THE BEST POSTER WINNER AT THE 2024 AND 2022 INFORMS QSR STUDENT POSTER COMPETITIONS AND THE BEST TRACK PAPER AWARD AT THE IISE ANNUAL CONFERENCE IN 2022.

TUESDAY, APRIL 22, 2025 | 3:30 PM – 4:30 PM
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