Award #1932574 - CPS:DFG Joint: Medium: Collaborative Research: Data-Driven Secure Holonic control and Optimization for the Networked CPS (aDaptioN)

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Plan to organize a workshop in the third year to demonstrate the science and technology of holonic control and optimization to enable resilient networked CPS infrastructure.

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networked infrastructures considering flexibility, scalability, tolerant to cyber events, data management and computing for a specific cyber-physical system: the distribution electric power grid specifically for its voltage and frequency control.

> We will target programs that focus on students from underrepresented groups: The Hispanic Youth Exploring Er camp and Pacific Northwest Louis Stokes Alliance for Mino



The objective of this project is to develop and validate holonic control and optimization algorithms for the critical cyber-physical

Distributed Delay-aware Control Architecture worked CPS model with latencies and disturbances				
$= Ax_{k} + B_{1}(d)u_{k} + B_{2}(d)u_{k-1} + v$ $= Ax_{k} + B_{1}(d)u_{k} + B_{2}(d)u_{k-1} + v$ $= Ax_{k}(\partial u_{k}) + Bx_{k}(\partial u_{k})u_{k} + Ex_{k}(\partial u_{k})\omega_{k}$	<u>insion</u>	d: vector of latencies v : physcial disturbances B ₁ ,B ₂ : Matrices are function		
$(a, u) = E_{pdf_{\theta}(\Delta \theta)} \left\{ l_N(x_{k+N k}; \Delta \theta) + \sum_{j=0}^{N-1} l_N(x_{k+j k}, u_k) \right\}$	$_{k+j k};\Delta\theta\Big)\Bigg\}$	Overall Cost		
aptive Model Predictive Control	C	ontributions: Adaptive MPC		
$\begin{array}{l} minimize_{u} \ J(x_{k}, u) \\ subject \ to: \ \widehat{x}_{k+j,i} = a_{k+j,i}^{T} \Lambda(\Delta\theta) \ , \\ h(\widehat{x}_{k+j,i}^{nom}, u_{k+j}, \Delta\theta \) \leq 0 \\ P_{i}(K_{1-\beta_{i}} Var[\widehat{x}_{k+j,i}] + E[\widehat{x}_{k+j,i}]) - q_{i} \leq 0 \\ u_{k+j} \in U \\ x_{k} = x(k) \end{array}$	 Com dete Exte while in ch 	putationally efficient methods rmine a_k nd to nonlinear dynamic system e minimizing approximation er nance constraints		

() vitching de multi- on systems ncies that	Valida Valida Bea Test syst Valida	Validation Plan tion with Prototype dated in Smart Grid Testbed (WSU) implemented in gleBone Black or Cisco Fog. bed includes standard ADMS,RTDS, Mininet/NS3 (for cyber em and cybersecurity emulation) and IEDs. tion for Metrics	
shed	Voltage violation metrics for proposed volt/var control.		
	🛛 Frea	quency violation metrics for proposed frequency control	
ch) dents.		Broader Impact (Potential impact)	
f Cougar		so far	
4-H Teens		 Number of downloads from Github: N/A Number of outreach activities for underrepresented broadening participation: 2 UGs as REU. 3 Female 	
ngineering (ority Particip	HYEE) ations	Students so far	



