Intelligent CyberInfrastructure
With Computational Learning in the Environment (ICICLE)

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http://icicle.ai
NSF-Funded AI Institute

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Vision

A national infrastructure that enables AI at the flick of a switch, ICICLE will:

- **Democratize AI** through integrated plug-and-play AI.
- Catalyze foundational AI/CI and transforming application domains.
- **Transparent and trustworthy** infrastructure for AI-enabled future,
- Address societal problems and national priorities
- Grow new generations of workforce
- Incubate companies with sustained diversity and inclusion

ICICLE will build a brighter future for all.
Main Thrusts

Use-Inspired Science
(Smart Foodsheds, Animal Ecology, Digital Agriculture)

- CI for Plug-and-Play AI
- Intelligent CI
- Field’s Edge to HPC/Cloud
- BPC/WFD for CI driven AI

Education and Outreach

Collaboration and Knowledge Transfer
The Rationale of ICICLE

Integrating a broad range of
- Scientists-in-the-field
- Engineers
- Educators
- Collaborative partners
- Institutions

under one roof enables
democratized,
adaptable,
plug-and-play AI
and long-tail science.
Research Plan: Overall Vision

Heterogeneities:
- Interface Heterogeneity
- Model Heterogeneity
- Data Heterogeneity
- Context Heterogeneity
- Compute Heterogeneity

Abstraction Layers:
- Conversational AI
- Model Commons
- Knowledge Graph
- Adaptive AI + Federated Learning
- Intelligent CI
Research Plan: Overall Vision

ICICLE
Intelligent CI

FOUNDATIONAL SYSTEMS AI

INTELLIGENT CYBERINFRASTRUCTURE

CI FOR AI
AI FOR CI-FOR-AI
SOFTWARE ARCHITECTURE AND DESIGN

VISUAL ANALYTICS FOR CI AND AI EXPLAINABILITY

PRIVACY, ACCOUNTABILITY AND DATA INTEGRITY

CO-DESIGN FOR USE INSPIRED SCIENCE
Research Plan: Foundational Systems AI

Knowledge Graphs
- Multimodal
- Spatio-temporal
- Auto construction
- Knowledge-based reasoning and pre-training

Model Commons
- KG-supported
- Precise profiling
- Flex Composition
- Versioning and provenance

Adaptive AI
- Context-aware
- Interactive
- Continual learning
- Distillation-based compression

Federated Learning
- Heterogeneity
- Applicability to a variety of models
- Context-aware
- Privacy-preserving and robustness

Conversational AI
- KG- and model-commons-aware
- Bootstrapping and adaptivity
- Multimodal contextual response

Crop Yield Model
Midwest
Corn, Strawberry…

Midwest Corn, Strawberry…

https://commons.wikimedia.org/wiki/File:Strawberry_field_at_Bedugul.jpg
https://pixabay.com/photos/strawberry-field-fruit-plant-3630814/
Research Plan: CI4AI

High Perf. Training
- Deep Learning Communication Optimization
- Deep Learning I/O Improvement
- Multi-level data/model/spatial parallelism

High Perf. Data Management
- Unified storage of data, model and hyperparameters
- Model lifecycle management for AI orchestration
- Data location transparency with migration

Edge Intelligence
- Adaptive Training/Inference and FL on Edge
- Novel Edge Offloading/Caching Orchestration
- Intelligent Anomaly Detection to improve QoS

AI-Adaptive Edge Wireless
- AI-adaptive, Predictable Comm. Capacity Allocation
- Predictable Wireless Comm. via Rateless-Coding & Multi-Modal/Path

Control and Coordination
- App/CI Interface Design
- Tapis Integration
- Production-ready Service Hardening and Optimization
Research Plan: AI4CI

- **Efficient plug-and-play**: Constantly adapt and optimize heterogeneous (cloud, HPC, and edge) CI to meet requirements of ICICLE applications, including digital agriculture and wildlife detection.

Intelligent Primitives (sparse/dense)
Product: High Performance Library
(Powered by AI to maximize the utilization of CI)

**Innovation**: Learn from hardware (e.g., SIMD width), network (e.g., bandwidth/latency), and data sparsity to extract best attainable performance.

**Utility**: (1) Portable high performance on diverse HPC systems (2) Usable at the backend of any other AI system.

Heterogeneous and rapidly evolving platform (CPUs, GPUs, Supercomputers, edge devices)
Research Plan: Use-Inspired Science
Research Plan: Complete ICICLE Software Architecture

- HPC & CLOUD DATA CENTERS
- WORKER AGENTS
- DATA TRANSFER
  - MESSAGE BROKER
  - SQL
- RESOURCE PROVISIONING
- JOB SCHEDULING
- PERSISTENCE
  - NOSQL
  - METADATA
  - APPS & FUNCTIONS
  - JOBS
  - HISTORY & PROVENANCE
  - AUTHN & AUTHZ
- SYSTEMS & FILES
  - STREAMS
- CONVERSATIONAL AI
  - KNOWLEDGE GRAPHS
- CONVERSATIONAL AI COMMONS
  - MESSAGE BROKER
- HTTP FRONT END APIs
  - JOB SCHEDULING
  - MESSAGE BROKER
  - HTTP
- END USER APPLICATIONS
  - CONVERSATIONAL AI
  - DATA VISUALIZATION
  - INTERACTIVE NOTEBOOKS, CLI, SDK, WEB APP
- RESEARCHERS & USERS IN THE FIELD
- EDGE & NEAR EDGE
  - MODELS
  - DATA
  - CONTROLLER
Broader Impacts: Workforce Development

- **Backbone Group**
- **Campus Champions**
- **Stakeholder partners**
- **Professional & K-12 partners**

**ICICLE Team**
- ICICLE Stakeholders
- Wider Community

**Content development and training in e.g., human and AI bias, transparency, integrity**
- Mentoring up and down organization
- Educational Fellows program
- Community based Participatory Research - food supply chain
- AI/CI in latticed credentials for professionals
- Young women summer camps

**Metrics and assessment ensure expanding success specially in target areas (STEM)**
Broader Impacts: Collaboration & Knowledge Transfer: A Phased Approach

Back-bone Group

ICICLE Team

Campus Resources

ICICLE Stakeholders

ICICLE user, researcher, government & policy partners

End users, new domains

Pathways and culture

Translation conceptualization

Product suite conceptualization (including gap analysis)

Translation and Deployment, Advise policy-makers

Community and industry dissemination and adoption
ICICLE will enable global leadership

- Integrates into the National CI Ecosystem
  - Short head and long tail science
  - Emerging applications
  - Maintains global leadership

- Integrative and Interoperable
  - Support across all CI components and emerging technologies
  - CI elements seamlessly composed

- Leverages existing recognized capabilities
  - Centers of Excellence, AI Institutes, Large Facilities

- Collaborative
  - Actively engage CI experts and domain scientists/CI users.

- Sustainable
  - Workforce Development, Broadening Participation, Collaboration and Knowledge Transfer
  - Benefits other institutes, large facilities, and all sciences beyond lifetime of award
Engaging the Community

Adopt ICICLE developed CI

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