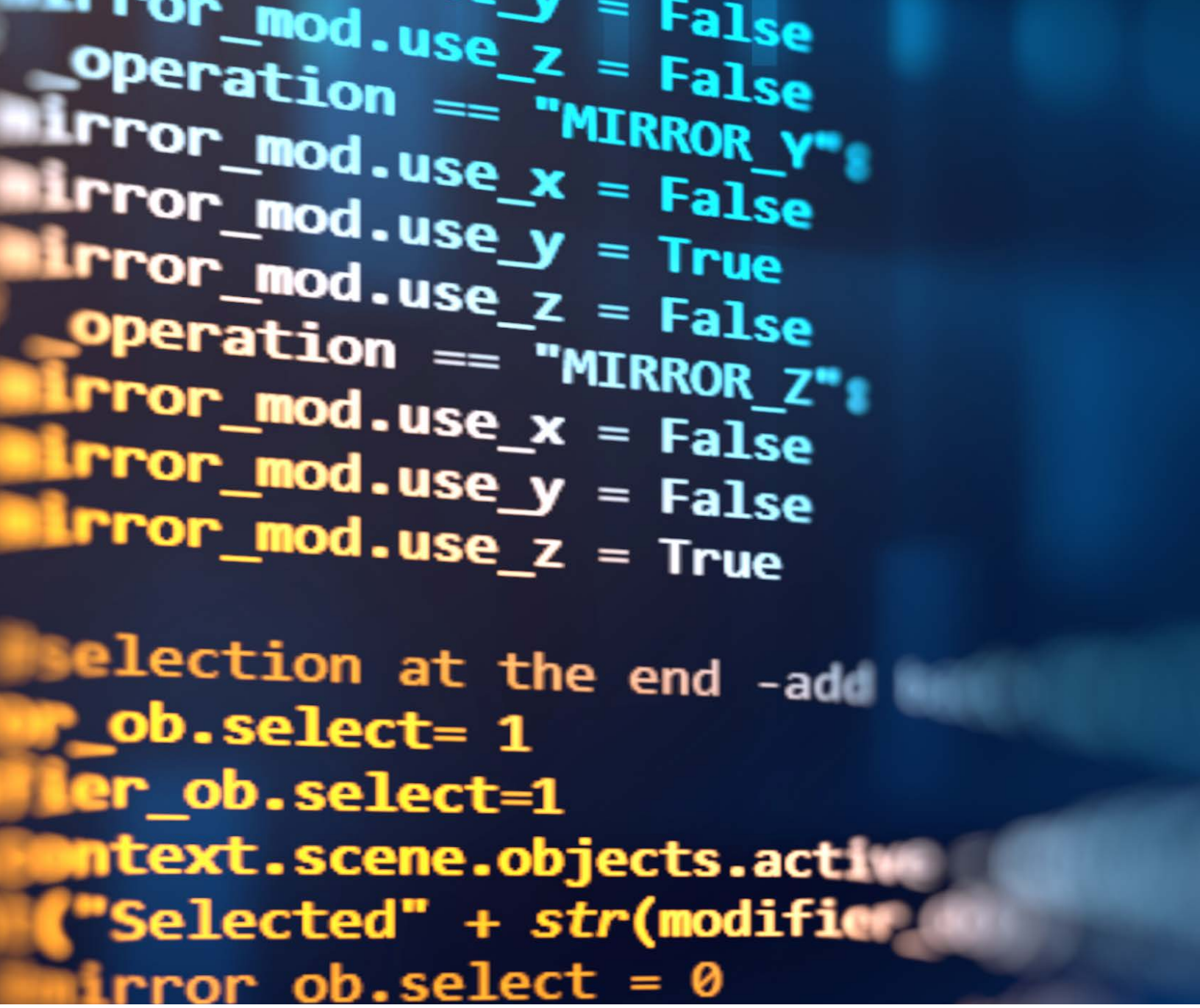


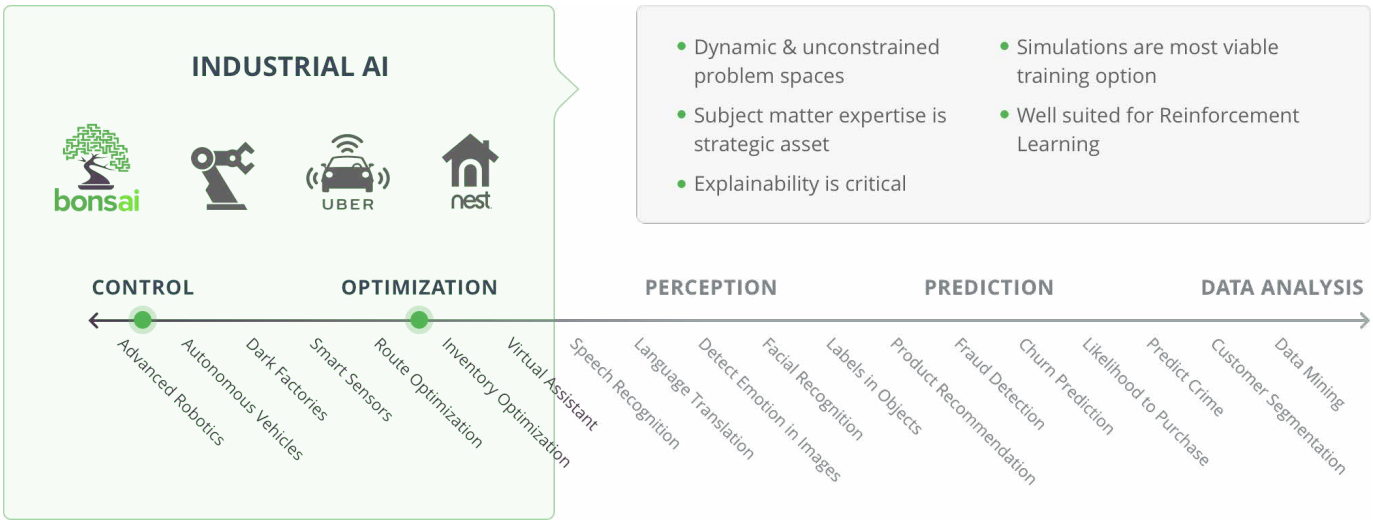
BONSAI WHITEPAPER

A fundamentally different approach for building intelligent industrial systems

bonsai

Enterprises of all sizes are actively evaluating artificial intelligence (AI) for a range of use cases beyond business-to-consumer (B2C) and data-centric applications. Shown on the left side of Table 1, there is a growing need for AI models that can inject greater intelligence, in the form of control and optimization, into sophisticated industrial systems. These systems take many different forms, including robotics, vehicles, factories, supply chains, logistics, warehouse operations, HVAC systems, oil exploration, and resource planning.

Table 1: Understanding the unique requirements of Industrial AI



Recognizing this trend, market analysts have begun forecasting the size of the opportunity for these intelligent industrial systems. IDC recently pegged the market for Cognitive & Artificial Intelligence Systems at $12.5B today, growing to $46.0B by 2020. David Schubmehl, Research Director, Cognitive Systems and Content Analytics at IDC, commenting on the opportunity for these AI-enabled systems, remarked:

> "Cognitive/AI systems are quickly becoming a key part of IT infrastructure and all enterprises need to understand and plan for the adoption and use of these technologies in their organizations."

Breaking down the market opportunity further, he noted:

> "From a technology perspective, the largest area of spending in 2017 ($4.5 billion) will be cognitive applications, which includes cognitively-enabled process and industry applications that automatically learn, discover, and make recommendations or predictions."

In a recent Economist article, The Growth of Industrial Robots, unit sales of industrial robots were cited to have increased by 15% in 2015, while revenues grew 9% to $11bn. In the article, ABI Research, a consultancy, forecasted industry sales to triple by 2025.

Meanwhile, a recent Forbes article discussed the size of the Industrial AI opportunity outside of robotics.

> "As sexy and shiny as robots are, the bulk of the value of AI in industrials lies in transforming data from sensors and routine hardware into intelligent predictions for better and faster decision-making. 15 billion machines are currently connected to the Internet. By 2020, Cisco predicts the number will surpass 50 billion. Connecting machines together into intelligent automated systems in the cloud is the next major step in the evolution of manufacturing and industry."

Across the different applications highlighted in Table 1, the business objective is very often to increase automation or enhance operational efficiency. In programming intelligence into these systems, organizations require industrial-strength AI models that can hold up to the unique requirements of these dynamic, unconstrained problem spaces. These models need to be programmable, adaptive and trusted.

Programming Intelligence Into Industrial Systems

Programming AI to improve control and enhance real time decision support for multidimensional, industrial systems quickly outstrips the capabilities of generic AI solutions. At the core of the issue is the lack of talent and/or tools that can combine an organization's subject matter expertise with complex machine learning technologies to build application-specific AI models.

Subject matter expertise, in the form of data, models, and simulations, is critical to understanding the different variables, behaviors, and constraints that drive the efficient operation of industrial systems. Paired with powerful machine learning libraries and techniques, like TensorFlow and reinforcement learning, specific domain expertise can significantly improve the prediction accuracy of produced intelligence models, as well as the automation and operational efficiency of targeted systems.

Table 2: Alternative solutions force unecessary tradeoffs

	Toolkits	Statistical Analysis Packages	API's	Bonsai Platform
Scope	✓	✓		✓
Explainable				✓
Reuse & Sharing	✓		✓	✓
Future Proof		✓	✓	✓

Up until now there has not been a platform available for enterprises to efficiently fuse together subject matter expertise and AI without requiring an advanced degree in machine learning. Consequently, enterprises have been forced to compete for the rare talent that can work with low-level AI toolkits, limit use cases to those with established APIs, or be unnecessarily constrained by black box solutions.

Applying a proven approach to a new problem

Bringing together expertise in neuroscience and developer platforms, Bonsai was founded in 2014 by Mark Hammond and Keen Browne with the vision of making intelligence a core component of every hardware and software application. Recognizing the shortage of data science talent capable of building sophisticated AI models, they developed a platform that abstracts away the complexity of libraries like TensorFlow, making the programming and management of AI models more accessible to developers and enterprises. Bonsai achieves this vision by applying a proven approach to a new problem, providing an abstraction layer above the low-level AI mechanics.

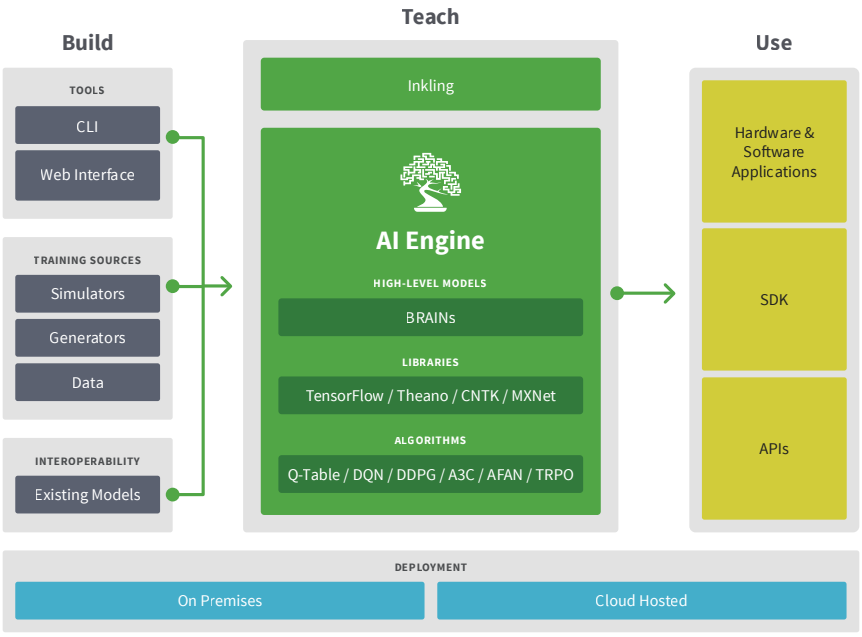
Before databases were commonplace, it was very difficult to work with data in sophisticated ways. Databases solved this problem nicely, but they didn't do it by providing a massive toolkit to tweak and tune all the low-level database mechanics. Instead, databases shifted up the level of abstraction, allowing developers to focus on the problem they were trying to solve.

AI suffers from a very similar problem today. The low level machine learning libraries and algorithms are very difficult to work with. To make AI more accessible, the answer is not to expose these vast, complex toolkits to developers. Just like databases did for data, Bonsai has shifted up the level of abstraction. Outlined in Table 3, Bonsai provides a developer with a special purpose programming language to codify the concepts unique to their problem domain, a runtime that generates and manages all the low level mechanics for them, and the libraries to connect the resulting AI models into hardware and software applications.

Table 3: Bonsai does for AI what databases did for data

UNDERSTANDING BONSAI RELATIVE TO COMPARABLE DATABASE CONCEPTS		
Core Design Principles	Database Equivalent	The Bonsai Platform
Create layer of abstraction to make AI accessible to less specifically trained engineers	Relational Model	Machine Teaching
Allow developers to program concepts & subject matter expertise unique to a specific problem (e.g. robotic control, supply chain optimization)	SQL	Inkling
Automate the management of underlying libraries and algorithms in order to generate and train the most appropriate high-level model	DB Engine	AI Engine
Easily author & debug code with visual tooling	SQL Mgmt. Studio	Mastermind
Interoperate with externally developed libraries to extend functionality of platform	CLR Stored Procedures, PL/Python, etc	Gearbox
Generate intelligence models that can be easily connected into hardware or software applications	Database	BRAINs

Table 4: The Bonsai Platform



The Bonsai Platform

Underpinning the complete Build-Teach-Use lifecycle of an AI model, the Bonsai Platform abstracts away the complexity of machine learning libraries like TensorFlow. Using Bonsai, developers, data scientists and subject matter experts can more effectively program and manage AI models.

Key benefits from using Bonsai to program your AI models include:

- **AI-enable your development team.** Bonsai allows developers to focus on programming concepts unique to a specific problem domain, leaving the management of complex, low level AI mechanics to the Bonsai AI Engine
- **Reuse and share your code and models.** Programming of intelligence at a higher level of abstraction enables code and model reuse. System libraries and shared models can be leveraged across development teams.
- **Debug, inspect, and refine your AI.** The high level models produced by Bonsai enable you to understand what contributed to a prediction, identify conceptual gaps and bugs, and constantly refine your models.
- **Build models independent of underlying algorithms.** As machine learning and deep learning algorithms evolve, your Inkling code can be recompiled and retrained to take advantage of low-level technology advances.
- **Host and collaborate on existing models.** Interoperability with existing machine learning models allows data scientists to expand the functionality of the platform, and extend these capabilities for use by your development teams.

How it works

Bonsai brings together state of the art techniques in machine teaching and machine learning, providing developers, data scientists, and subject matter experts with the tools to teach the desired intelligence to a system, while automating the complex, low level mechanics of machine learning. With the Bonsai Platform, enterprises can more efficiently build application specific AI models that increase the automation and operational efficiency of sophisticated industrial systems.

Starting with Inkling, Bonsai's special purpose programming language, developers codify the specific concepts they want a system to learn, how to teach them, and the training sources required (e.g. simulations, data). We refer to this technique as Machine Teaching. Each Inkling program developed with this approach is fed into the Bonsai AI Engine, where it is paired with state of the art machine learning libraries (e.g. Tensorflow) and techniques (e.g. reinforcement learning) to generate and train the most appropriate model. The resulting high-level model can then be connected into your hardware or software application through Bonsai provided libraries. Each model is available for ongoing debugging and refinement, and can be repurposed for use in other applications.

Step-By-Step

An AI learns from interacting with a simulation or analyzing recorded data. Using the Bonsai Platform, each AI model is created by following the three step sequence outlined below.

Step 1: Build

- Create a BRAIN - a high level model of the concepts to be learned and a set of lessons that can be used to teach them - using Bonsai's Inkling programming language.
- Specify any pertinent training sources, such as data or simulations, that will be used in conjunction with the lessons as part of teaching the model.
- Filter data, configure simulations, or otherwise prepare the training materials as appropriate for each lesson.
- Establish objectives used to evaluate the AI's mastery of each concept. This is typically a scoring function assessing the quality of the AI's prediction versus desired results.
- Load the resulting project (the collection of your Inkling code, data, and simulations) into the Bonsai AI Engine using Bonsai's CLI, IDE, or web based tooling.

Step 2: Teach

- Start the training of your BRAIN in the Bonsai AI Engine - this will generate an appropriate low level model for your project (e.g. a deep learning neural network topology).
- Assess training status throughout the training of your BRAIN.
- Refine and iterate your project as desired; rerun training of the BRAIN as needed.

Step 3: Use

- Connect your BRAIN via Bonsai provided libraries to your software or hardware application (just like you would connect a database to your application).
- Your application will be able to stream in data and receive predictions from your BRAIN.
- Your Inkling code can be leveraged in other applications.

Use Cases: Increase the automation & efficiency of industrial systems

The Bonsai Platform is best suited for programming AI models that can inject greater intelligence, in the form of control and optimization, into sophisticated industrial systems. Models produced with the Bonsai Platform help increase the automation and operational efficiency of these systems. Current focus use cases for the platform include:

- Intelligent Systems. The complex and unconstrained problem spaces that industrial robotic systems must navigate, including factory floors and warehouse operations, require increased automation capabilities and more intelligent, adaptive controls. Due to the inherent complexity of low-level AI libraries and algorithms, only an extremely small subset of data scientists can build these dynamic systems today. With Bonsai, your existing development teams can program AI models to increase the control and automation of these advanced robotic systems.
- Intelligent Operations. Manually modeling and optimizing every variable within multi-dimensional business systems -such as a supply chain, logistics, or HVAC - quickly outruns the time, budget, and skillset of many development teams. With Bonsai you can leverage internal skills and expertise to program AI models that improve prediction accuracy and real time decision support. This results in greater operational efficiency from sophisticated industrial systems.

Getting Started

Bonsai has been specifically designed to provide enterprises with a complete platform for more effectively programming and managing intelligence models that increase the automation and operational efficiency of industrial systems.

If you think you have a use case that could be a fit for the Bonsai Platform, visit https://bons.ai/getting-started learn how to get started.

About Bonsai

Bonsai offers an AI platform that empowers enterprises to build and deploy intelligent systems. By completely automating the management of complex machine learning libraries and algorithms, Bonsai enables enterprises to program AI models that improve system control and enhance real-time decision support. Businesses use these models today to increase automation and improve operational efficiency of industrial systems including robotics, manufacturing, supply chain, logistics, energy and utilities. To learn more, please visit: https://bons.ai/ or follow us on Twitter @BonsaiAI.

bonsai