



# BONSAPPS

## AI-as-a Service for the Deep Edge

### D5.1 User Support Framework

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Author(s)	Miguel de Prado (BCA), Nikola Milojevic (BCA), Vladimir Mujagic (BCA), Emily Carroll (ISDI)
Contributor(s)	Tim Llewellynn (BCA), JM Bonnefous (BCA)
Editor(s)	BCA
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# Abbreviations

**EC:** European Commission  
**DoA:** Description of Action  
**GA:** Grant Agreement  
**SME:** Small and Medium Enterprise  
**BMP:** Bonseyes AI Marketplace  
**USF:** User Support Framework  
**DPE:** Developer Platform Environment  
**BSP:** Board Support Package

# Executive Summary

This document includes the structure and the first content of the Bonseyes AI Marketplace's User Support Framework (USF). The USF is intended to build a Developer Community to access and create BonsApps services and tools. The content has been internally released in beta version and it is ready to be used by 3<sup>rd</sup> party users as of 25<sup>th</sup> October.

Currently, the USF contains five main support tools: Developer Community Area, AI Challenges, AI Assets, Developer Platforms, and a Certificate supported Massive Online Open Course (MOOC) platform.

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# 1 Introduction

The Bonseyes AI Marketplace is a web platform that connects researchers, developers, and companies to procure, collaboratively build, and trade AI Applications. Its goal is to facilitate collaboration between researchers and industry to speed up the process of building and deploying AI-base solutions to solve real-world challenges defined by the industry.

The Bonseyes AI Marketplace will provide to the researchers, data scientists, developers, and industries the various number of AI Artifacts, e.g., AI papers, datasets, assets, applications and embedded boards. Users can search, browse, and bookmark AI Research from the collection, as well they can create, publish, download, sell and buy AI Artifacts from the AI Marketplace. Industries can create AI challenges and open a tender for its solution. On the other side, developers and data scientists can join the challenge with the aim to solve the challenge and monetize their expertise. Figure 1 depicts the numbers of available AI Artifacts on the AI Marketplace.

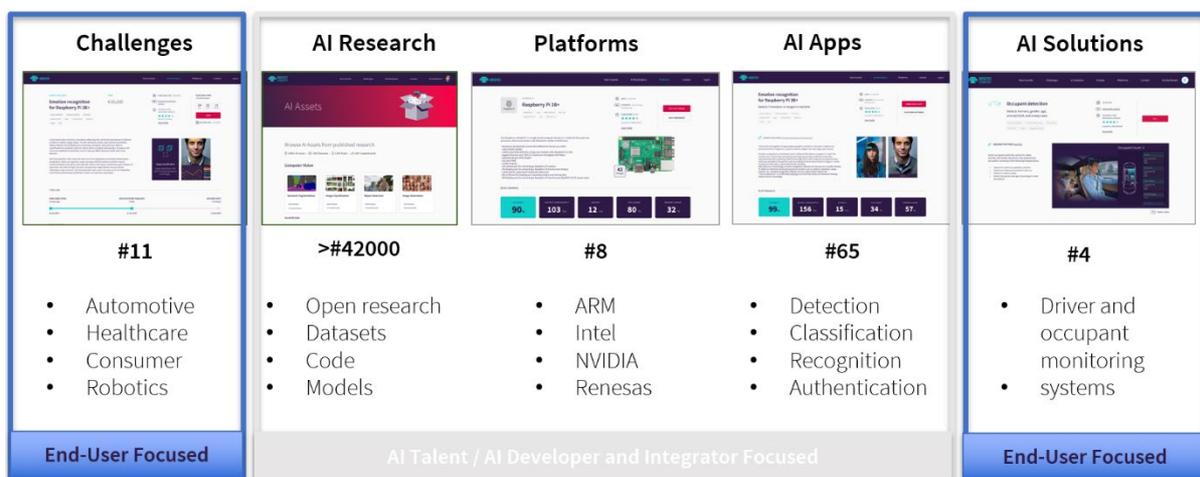


Figure 1 Marketplace Artifacts

The current version of Bonseyes AI Marketplace defines and targets following users for the BonsAPPS services layer:

- **Researchers:** is someone who conducts research, i.e., an organized and systematic investigation of the topics related to the domain of the AI. He is a publisher of the AI Research or AI Asset.
- **Innovators:** are individuals who represent a company, SME or academic institution that would like to solve a data-driven problem using AI technologies. Innovators are creators of the challenge, providing a description of the problem, data, resources constraints, and target performances.
- **Data Scientists:** are highly skilled professionals or researchers in the field of data science. They are the creators of AI Artifacts and AI Models that enables the creation of AI Apps as a solution to a challenge.
- **Developers:** are highly skilled professionals experienced with the deployment process of the AI Models into the various hardware platforms. They are creators of AI Applications that embed AI Models on specific Developer Platforms containing Target Hardware, which may include meeting non-functional requirements in embedded systems.
- **Integrators:** are highly skilled companies or professionals in the field of deployment and integration of the AI Apps into the final industry solution. They create AI Solution that

composes multiple AI Apps in conjunction with the supplementary user interface, platform integration, synchronization, and orchestration code.

For the BonsAPPS AI-as-a-Service layer (AlaaS) to be fully operative for third-party use, the technology development process described above must run in parallel to the development of appropriate mechanism guiding the users of AlaaS. Those mechanisms must be scalable and provide appropriate support to both end-users and AI Talents<sup>1</sup> in a way that does not require high-intensity involvement by technical experts. The User Support currently have the following components:

- **Developer Community Area:** The developer community represents one of the major parts of the Bonseyes AI Marketplace with the goal to provide AI Research [Chapter 3], namely, a collection of AI paper and associated open-source implementations, open-source data collections (datasets) in different modalities and for different domains. The Developer Community also provides User Support Documentation [Chapter 2], which provides detailed user guides and workflows and networking opportunities through the community part in order to connect with the individuals or organizations that are part of the AI Marketplace.
- **AI Challenges:** AI challenges are problems or specific use cases driven by the Industry or Academia, which do not yet have a solution. An AI Challenge needs to specify the description of the problem as well as the specifications that would be needed to solve such challenge, e.g., evaluation data and procedure, end-target deployment platform, throughput, accuracy, etc.
- **AI Assets:** A Bonseyes AI Asset represents an implementation of the research paper employing the deep learning deployment-centric framework called AI Asset Container [Chapter 4]. An AI Asset Container provides a set of services and standardized building components that facilitates and accelerates the development of AI systems for the resource constrained low power devices. The AI Asset Container provides a complete Python-based workflow for end-to-end deployment of Deep Learning models to supported embedded hardware target platforms.
- **Developer Platform:** A Developer Platform is a digital package containing the full software stack and documentation required to procure, set up and control target hardware for the execution of AI applications [Chapter 5]. Moreover, the platform provides a cross-compilation environment and tooling that can create executables for the target hardware on the developer workstation.
- **Certificate-supported Massive Online Open Course (MOOC) platform and 3 modules:** turning the existing User Documentation and Tutorials into a training cycle that will serve as a quality system to certify the proficiency of BMP users (end users, AI Talents) in the use of the AI-aa-S [Chapter 6]. This is also expected to be of special relevance to support the validation of entities offering AI services willing to participate second round of experiments. The implementation of the first modules is planned for the end of the first year, right before the start of the 1<sup>st</sup> support programme.

## 2 User Support Documents

### 2.1 Documentation

Bonseyes AI Marketplace documentation is divided in three different blocks:

- **Bonseyes CLI tool setup:** The Bonseyes CLI Tools is the command line interface that will enable users and developers to interact with the Bonseyes AI Marketplace This documentation will describe the steps to install the Bonseyes CLI Tool.

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<sup>1</sup> AI Talents are researchers, PhDs/post-docs, engineers/developers, or data scientists that have capabilities to resolve AI challenges

- **Bonseyes User Guide:** The User Guide represents the reference developer's documentation that explains how the user can start using the Bonseyes Platform, including AI Marketplace. It will provide comprehensive guide how to create, use and manage AI Artifact on the local workstation and AI Marketplace. All features of the User Guide are depicted in the Table 1.
- **Bonseyes Developer Guide:** The Developer Guide will expand the User Guide for the user to develop or create new AI Artifacts. This guide is intended for AI Talents with expertise in the field of deep learning. All features of the Developer Guide are depicted in the Table 2.

Table 1 User Guide Features

Tutorial	Format
Setup Developer Workstation	Text
How to obtain a platform from the marketplace	Text, video
How to setup a target hardware	Text, video
How to obtain an AI Asset from the marketplace	Text, video
How to benchmark an AI Asset	Text, video
How to obtain an AI app from the marketplace	Text
How to benchmark AI App	Text, video
How to obtain a challenge from the marketplace	Text, video
How to create challenge	Text
How to upload a challenge to the marketplace	Text, video

Table 2 Developer Guide Features

Tutorial	Format
How to create a platform package	Text
How to upload a platform to the marketplace	Text, video
How to create an AI Artifact package	Text
How to create Data Tool	Text
How to create Evaluation Tool	Text
How to use AI Asset Container Generator	Text, video
How to use AI Asset services for the deep edge	Text, video
How to generate AI App	Text, video
How to upload AI app to the marketplace	Text, video

## 2.2 Blog

As part of the User Support Documents, Bonseyes will provide a community-driven blog that will present articles and tutorials. Articles that are going to provide text-based content discussing specific topics and Tutorials will represent a practical step-by-step guide.

## 3 AI Research

Research in the domain of Artificial Intelligence represents scattered resources across the internet, making searching, finding, and following specific research artifacts hard. In order to mitigate that problem, Bonseyes AI Marketplace acts as an aggregator platform, allowing one with an interest in it to find, browse and follow latest research in the AI domain. Research resources on the Marketplace are split into two categories:

- Research that represents papers and associated implementations of the papers,
- Datasets that provide references to the publicly available collections of domain data.

From developers' and data scientist perspective, they represent a starting point that can help in the process of AI systems development.

### 3.1 Papers & Paper Implementations

In order to facilitate and accelerate the development of the AI systems, Marketplace will provide a collection of the AI research that will be categorized by AI category (e.g., Computer Vision, Natural Language Processing), each category is sub-categorized by the AI task, e.g., Image Classification, Scene Segmentation, see Figure 2.

For the specific AI task related AI Research works are ordered based on the benchmark results, benchmarks are data-driven and consist of specific dataset and evaluation metrics to assess the model performances. AI Research is ordered by most credible benchmarks, providing leaderboard details of the evaluated models. Following that approach, AI Talents can quickly find the state-of-the-art AI Research works.

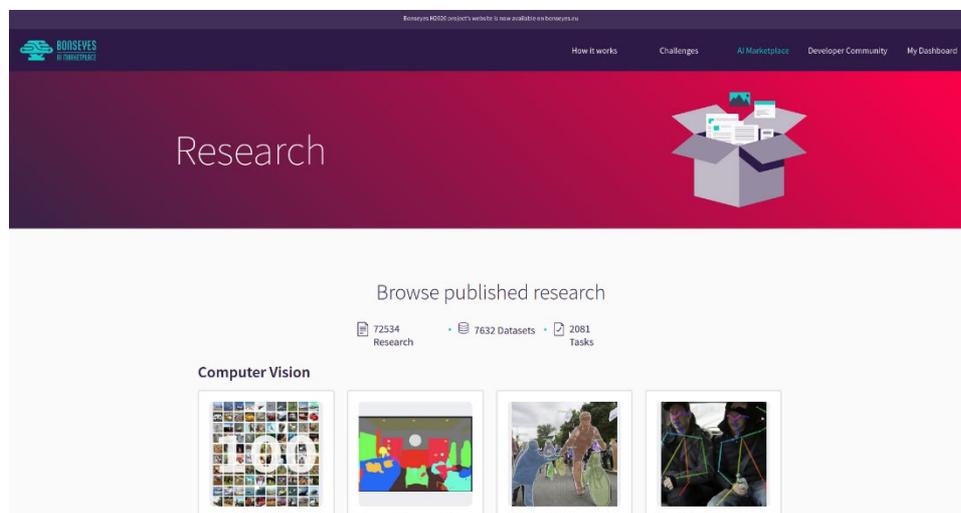


Figure 2: Research landing page on the Bonseyes AI Marketplace

The Bonseyes AI Marketplace provides additional information for AI Research, which provides insights of the deployment capabilities of the AI models. The insights are depicted in in Figure 3 and are the following:

- Community relevance of the implementation by presenting GitHub stars
- ML framework that has been used for the implementation
- Colab implementation for the quick demonstration
- Dockerization of the implementation
- Interoperability by means of ONNX model formats
- Support of the ONNX model in the Bonseyes's inference engine: LPDNN.

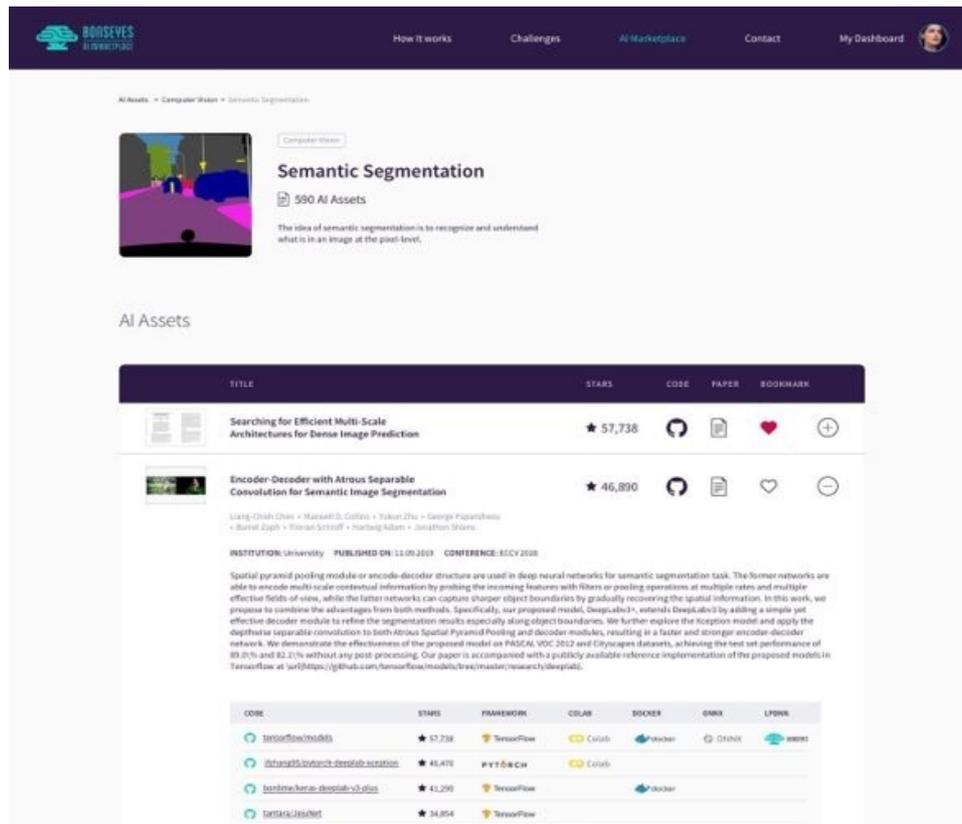


Figure 3: Deployment capabilities of AI Research works

Information of the deployment capabilities ease the process of finding suitable AI Research for industrialization using ML deployment framework AI Asset Container [Chapter 4.1.1].

### 3.2 Datasets

Datasets represent a publicly available collection of data that can be in different modalities and for different domains. On the Marketplace, datasets will provide general information of the dataset and references to the dataset sources. On the Datasets page, AI Talents can explore and find suitable datasets in order to develop models that solve specific AI challenges.

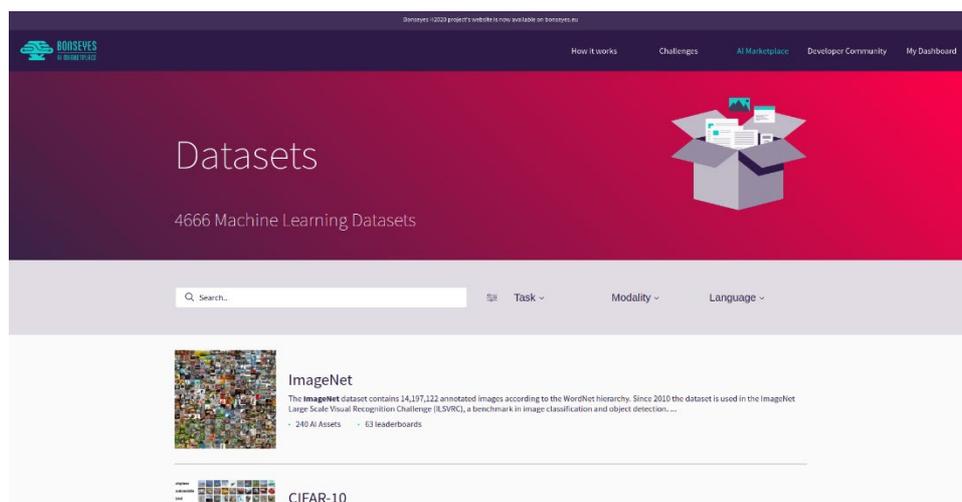
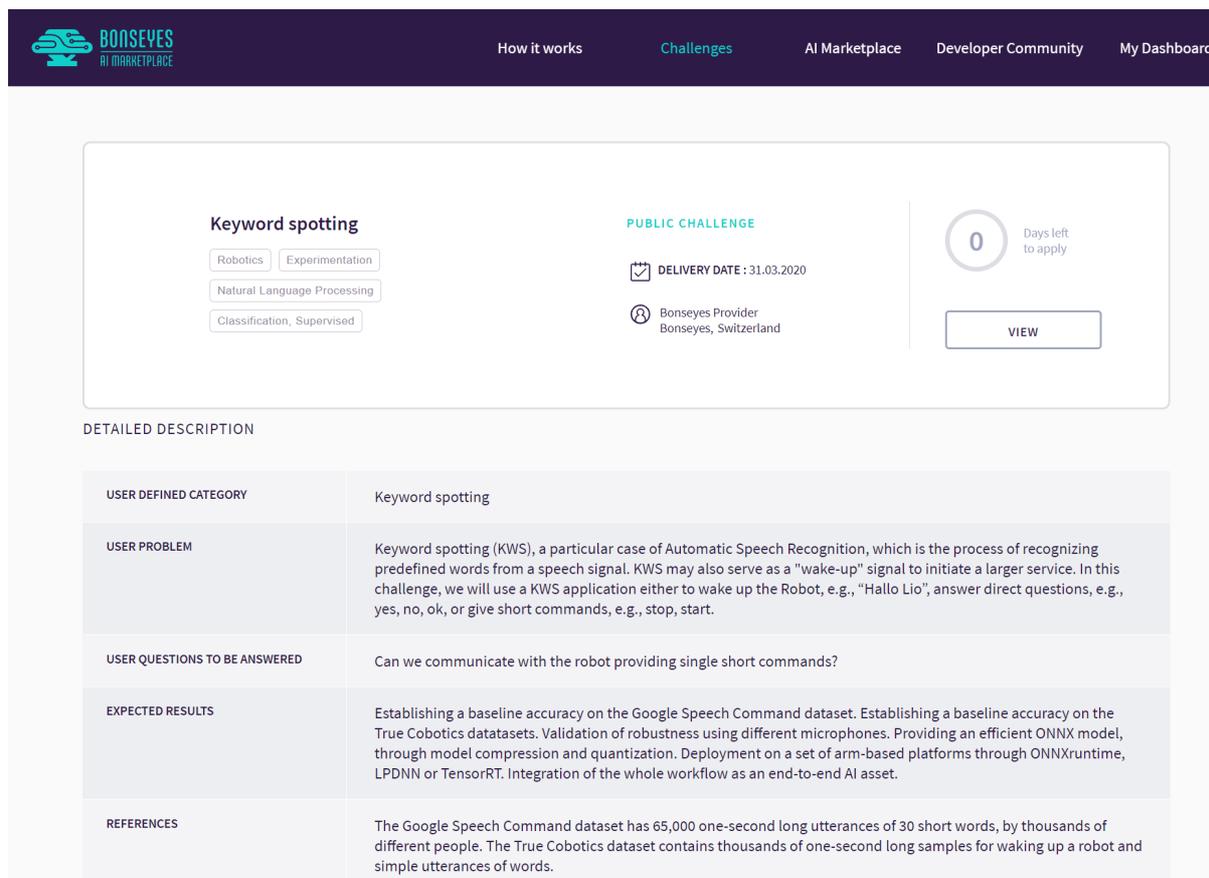


Figure 4: Dataset landing page on the Bonseyes AI Marketplace

## 4 AI Challenges

AI challenges are problems or specific use cases driven by the Industry or Academia, which do not yet have a solution. Currently, the Bonseyes AI Marketplace offers the users to visualize open AI Challenges. In future releases, the users will be also able to create and publish their own AI Challenges.

An AI Challenge, as shown in Figure 5, needs to specify the description of the problem as well as the specifications that would be needed to solve such challenge. An initial page displays all current open AI challenges with a few descriptive keywords, the due date, and the provider. By clicking into the specific AI Challenge, detailed descriptions are provided about the problem, the evaluation data and procedure, end-target deployment platform, throughput, accuracy, etc.



The screenshot shows the Bonseyes AI Marketplace interface. At the top, there is a navigation bar with the Bonseyes logo and menu items: "How it works", "Challenges", "AI Marketplace", "Developer Community", and "My Dashboard". The main content area displays a challenge card for "Keyword spotting".

**Keyword spotting**

- Robotics
- Experimentation
- Natural Language Processing
- Classification, Supervised

**PUBLIC CHALLENGE**

- DELIVERY DATE : 31.03.2020
- Bonseyes Provider: Bonseyes, Switzerland
- 0 Days left to apply
- [VIEW](#)

**DETAILED DESCRIPTION**

USER DEFINED CATEGORY	Keyword spotting
USER PROBLEM	Keyword spotting (KWS), a particular case of Automatic Speech Recognition, which is the process of recognizing predefined words from a speech signal. KWS may also serve as a "wake-up" signal to initiate a larger service. In this challenge, we will use a KWS application either to wake up the Robot, e.g., "Hallo Lio", answer direct questions, e.g., yes, no, ok, or give short commands, e.g., stop, start.
USER QUESTIONS TO BE ANSWERED	Can we communicate with the robot providing single short commands?
EXPECTED RESULTS	Establishing a baseline accuracy on the Google Speech Command dataset. Establishing a baseline accuracy on the True Robotics datasets. Validation of robustness using different microphones. Providing an efficient ONNX model, through model compression and quantization. Deployment on a set of arm-based platforms through ONNXruntime, LPDNN or TensorRT. Integration of the whole workflow as an end-to-end AI asset.
REFERENCES	The Google Speech Command dataset has 65,000 one-second long utterances of 30 short words, by thousands of different people. The True Robotics dataset contains thousands of one-second long samples for waking up a robot and simple utterances of words.

Figure 5: AI Challenge for Keyword Spotting

## 5 AI Assets

Bonseyes AI Asset represents an implementation of the research paper employing the deep learning deployment-centric framework called AI Asset Container. An AI Asset Container provides a set of services and standardized building components that facilitates and accelerates the development of AI systems for the resource constrained low power devices.

A Bonseyes AI Asset Container provides a complete Python-based workflow for end-to-end deployment of deep Learning models to supported embedded hardware target platforms, AI Asset Container Dependency Profiles for target environments to enumerate target runtime environments on various target hardware platforms supported by Bonseyes Developer Environments (DPES),

containers for deep learning providing a stable set of pre-installed software packages, and a definition of a virtualized host environment to ensure compatibility when executing and running Bonseyes AI Asset Containers on various host systems.

A common problem in deployment to the deep edge is that when training and optimizing models in a cloud or host environment, often a model is created with a set of dependencies that does not match the target hardware platform environment. These dependency differences can create subtle and accumulative errors which make exact replication of models at deployment difficult and make debugging model performance complex and sometime impossible. Additionally specialized tools are often required to program specialized hardware circuits which may require a very specific dependency set to function correctly.

To alleviate these developer “pain points”, the AI Asset container provides dependencies profiles for target environments for deep edge platforms such as Raspberry Pi, NVIDIA Jetson devices computing platforms. The dependency profile contains versioning information of common middleware and driver components so that the Bonseyes AI Asset Container can mirror the target deployment environment as closely as possible.

Supported dependency profiles include:

- **Workstation / Server / Laptop (x86\_64)**  
AMD/Intel CPU and NVIDIA GPU
- **NVIDIA Jetson devices (aarch64)**  
Jetson Xavier AGX, Jetson Xavier NX, Jetson Nano
- **Raspberry Pi (arm64v8)**  
Raspberry Pi3, Raspberry Pi4
- **RISC V Architectures**  
Greenwaves GAP8 Multicore processor

Supported software version management includes:

- Python
- Pytorch
- CMake
- OpenCV
- GCC
- CUDA, cuBLAS, and cuDNN
- LPDNN
- TensorRT and ONNX-TensorRT
- ONNX and ONNX Runtime
- Nemo –Dory optimization frameworks

## 5.1 AI Assets Framework

AI Asset deployment framework enables accelerated deployment of deep learning models to resource constrained low power embedded systems (Deep Edge). These containers deliver powerful and easy-to-deploy building blocks for creating complex AI models that can be deployed on cyber-physical systems. By taking care of many of end-to-end tooling dependencies and providing standardized interfaces, Bonseyes AI Asset Containers enable users to focus on producing optimal solutions while allowing faster feedback during the implementation of end user requirements.

In summary, the goal is to facilitate easier deployment to the deep edge with the Bonseyes AI Marketplace.

AI Asset services include:

- **Models:** Provides model storage and model summaries.
- **Training:** Provides ability to retrain model or create new trackable experiments.
- **Quantization:** Provides ability to perform training and non-training aware quantization using Pytorch and TensorRT.
- **Evaluation:** Provides ability to evaluate models using different engines, input sizes and backbones.
- **Export:** Provides ability to export pretrained Pytorch models to ONNX or TensorRT.
- **Test:** Provides framework for automated testing of implemented features.
- **Data processing:** Provides ability to process data in a form of image, video or camera stream.
- **Benchmarking:** Provides ability to evaluate all models and get detailed information about accuracy and model performance on target device.

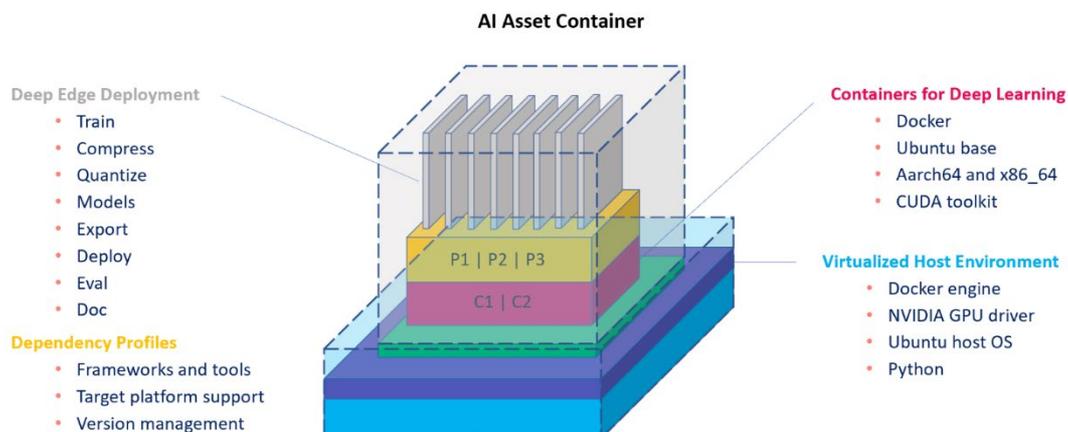


Figure 6: AI Asset container architecture

## 5.2 AI Assets CLI

Manipulation of developed AI Assets can be done using AI Assets CLI that allows user to initialize AI Asset container on target platform and then use services provided by deployment framework such as export, evaluation, processing, and benchmark.

Detailed usage instructions are provided in official AI Asset CLI docs:

[https://bonseyes-opensource.gitlab.io/aiassets\\_cli/](https://bonseyes-opensource.gitlab.io/aiassets_cli/)

Example usage is provided in official Bonseyes documentation for AI Assets:

<https://bonseyes-opensource.gitlab.io/documentation/pages/aiasset.html>

## 5.3 AI Asset Examples

At this development stage, two AI Asset examples are provided for 3D face landmark detection and whole body pose detection:

1. Whole body pose detection – 133 keypoints  
[https://bonseyes.gitlab.io/assets/bonseyes\\_openpifaf\\_wholebody](https://bonseyes.gitlab.io/assets/bonseyes_openpifaf_wholebody)
2. 3D face landmark detection – 68 keypoints  
[https://bonseyes.gitlab.io/assets/bonseyes3ddfa\\_v2](https://bonseyes.gitlab.io/assets/bonseyes3ddfa_v2)

## 6 Developer Platforms

A Developer Platform is a digital package containing the full software stack (operating system, drivers, middleware components, etc.) and documentation required to procure, set up and control target hardware for the execution of AI apps (de Prado et. Al.). Moreover, the platform provides a cross-compilation environment and tooling that can create executables for the target hardware on the developer workstation.

The platforms are composed of various components:

- **Support docker:** the container used to build the platform package and setup target hardware.
- **Builder docker:** the container used to cross-compile binaries for the target hardware.
- **Manager docker:** the container used to control the target hardware.
- **Clean metadata:** the full metadata that is used for the listing on the marketplace.

Currently, the following platforms are supported:

*Table 3 Supported Developer Platforms*

Name	Vendor	Version
x86_64-ubuntu18	Ubuntu	V1.0
x86_64-ubuntu20	Ubuntu	V1.0
raspberrypi4b_64-ubuntu20	Raspberry Pi	V1.0
jetson_nano-jetpack4.4	Nvidia	V1.0
GAP8 RISC-V processor	Greenwaves	V1.0

### 6.1 Developer Platform Environment (DPE)

A DPE is a package containing the environment, e.g., tools and workflows, to help the user employ a developer platform. A DPE has the objective of walking the user through the steps of building a Developer Platform, setting up the embedded hardware and test a sample application on it to make sure of the correct operation of the system.

Each DPE contains three elements:

- **Board Support Package (BSP):** Package containing docker images, drivers and toolchains for the target embedded platform. This element is given as a zip file.
- **Bonseyes CLI tool:** Command Line Interface tool that allows the user to perform actions to follow the workflow. This element is given as a zip file.
- **Sample application:** “Hello-world” sample application to test the correct operation of the of the DPE workflow. This element is given as a zip file.

A BSP is organized as follows:

- Platform-sources.zip
- Docker-images/
  - PlatformName-manager.tar
  - PlatformName-support.tar
  - PlatformName-builder.tar

A DPE is given as zip file, which is currently stored offline in one of the project’s repositories.

Note: DPEs will be moved to the BMP once this feature is supported.

User documentation to follow a DPE workflow has been posted in the Bonseyes GitLab:

<https://bonseyes-opensource.gitlab.io/documentation/pages/dpe.html>

Note: This documentation is intended to be moved to the BMP once the support is ready.

## 6.2 DPE workflow

A DPE workflow consists of three steps:

### 6.2.1 Requirements

The user must comply with specific requirements to successfully use the DPE without encountering any issues. If those requirements are not met, this step guides the user through the installation and preparation of the different packages and tools that are needed to complete the DPE workflow. The requirements can be summarized in the following elements:

- Linux environment: Ubuntu18 or Ubuntu20
- Docker
- Git and Git LFS
- Python packages

For more information, see requirement step on:

<https://bonseyes-opensource.gitlab.io/documentation/pages/dpe.html#requirements>

### 6.2.2 Setup

Once all required software packages are installed, it is possible to start the setup. The main steps of the setup process are the following:

1. Decompression of files
2. Installation of Bonseyes CLI Tool
3. Load of docker images
4. Build DPE
5. Set up target hardware

For some platforms, a web-based wizard is provided which leads the user through the necessary steps to build and setup the platform:

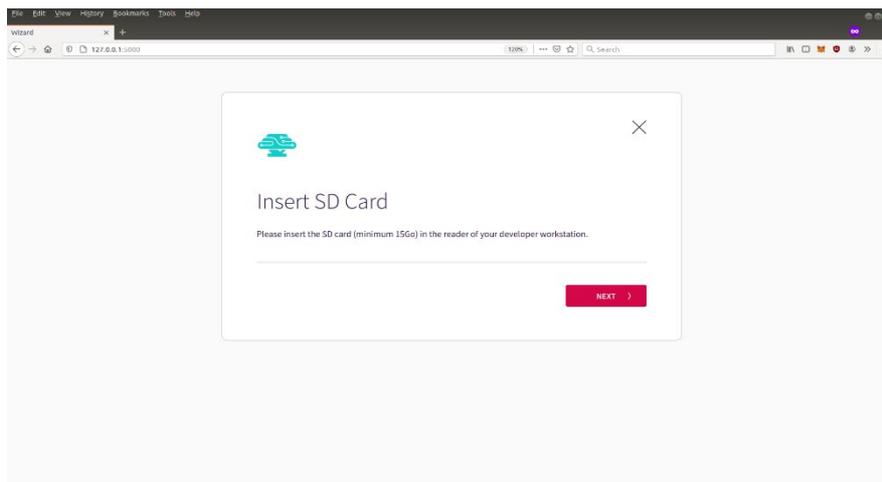


Figure 7: Wizard to flash target hardware

To deploy on some platforms, the user may need to flash an SD card. This workflow provides detailed information about the process as well as troubleshooting in case of technical problems with the SD card.

For more information, see setup step on:

<https://bonseyes-opensource.gitlab.io/documentation/pages/dpe.html#setup>

### 6.2.3 Test

A “Hello-world” sample application is provided to test the correct operation of the of the DPE workflow. The main steps of the test process are the following:

1. Cross-compile application for target platform
2. Copy binary on the target platform through Bonseyes CLI tool
3. Execute binary on the target platform

For more information, see test step on:

<https://bonseyes-opensource.gitlab.io/documentation/pages/dpe.html#test>

## 7 MOOC platform

As part of the support materials available in BonsAPPS, users will have access to courses that will help them learn how to use the assets available on the BMP.

### 7.1 Structure and content of the courses

A total of three courses will be developed. These courses will follow a sequential journey, moving from a basic level to intermediate and, finally, to an advanced level.

The specific content of the courses has yet to be developed; however, production of the first course is underway. The first draft of a potential table of contents can be seen below.

#### *Introduction*

*Description of the course, basic contents of the course organisation, etc*

#### *Section A: Introduction to AI assets*

*Deep learning concepts and workflow:*

*Data collection*

*Training*

*Deployment*

*Challenges of porting deep learning to embedded devices:*

*Large computational and memory requirements*

*System dependencies*

*High expertise needed*

*AI assets for accelerated deployment of deep learning models to resource constrained low power embedded systems:*

*AI asset introduction*

*AI asset workflow*

#### *Section B: AI assets workflow (Set-up, training & Optimisations)*

*Clone an AI asset on local machine, install dependencies (git, docker)*

*Build docker images based on platform choice*

*Training example*

*Download dataset*

*Train model*

*Compress & quantise example*

#### *Section C: AI assets workflow (Export and platform setup)*

*Refer to trained model or show pre-trained model if already available*

*Export to ONNX or TensorRT*

*Set up platform*

*Connect to BMP, install cli-tool*

*Download platform*

*Set up platform*

*Section D: AI assets workflow (Deployment)*

*Pull docker image on embedded device*

*Download pre-trained models or move converted model from previous section to embedded device*

*Test model*

*Explain different execution options for demo*

*Image*

*Video*

*Camera*

*Http*

*Run demo*

*Evaluation*

*Run evaluation tool*

*Wrap up results and submit*

The second course will build on the skills obtained here, and the third will build upon the first two. Upon the completion of each course, the user will be issued a certificate as described in the following section.

## 7.2 The MOOC platform

The three courses will be hosted on a platform that will be custom-built for the BonsAPPS project. This platform will be built on Open edX, a platform designed by experts at Harvard and MIT specifically for hosting university-type courses.

The BonsAPPS learning platform is referred to as a MOOC platform, since its offering is Massive, Open, Online Courses (MOOC).

While the specific material of the courses will be created by the technical experts on the BonsAPPS consortium, the content itself will be created by ISDI's team of expert content creators. Courses will integrate multimedia learning, including video, text, presentations, and quizzes. As mentioned above, successful completion of each course will be indicated by the emission of a certificate.

The first course is intended to be ready for release by the beginning of M12.

## 8 Conclusions

This document has introduced the User Support Framework of the Bonseyes AI Marketplace and the content that is available to date (released in beta version and it is ready to be used by 3<sup>rd</sup> party users). Currently, the USF contains five main support tools: Developer Community Area, AI Challenges, AI Assets, Developer Platforms, and a Certificate supported Massive Online Open Course (MOOC) platform.

The document is intended to show the structure and ground of the Bonseyes AI Marketplace that will be used to create a Developer Community where users can access to the Bonseyes AI Marketplace and interact with the tools.

## References

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