LUCA COVIELLO

Consortium GARR | THE ITALIAN EDUCATION & RESEARCH NETWORK

FONDAZIONE BRUNO KESSLER

MPBA PREDICTIVE MODELS FOR BIOMEDICINE & ENVIRONMENT

Multimodal Deep Neural Networks and Precision Agriculture for Food Quality Monitoring

GIORNATA DI INCONTRO
BORSE DI STUDIO GARR
"ORIO CARLINI"
ROMA

Roma, 27/06/19

XI Borsisti Day

Problems in Agriculture

Demand for food +50% between 2012 and 2050

Only few opportunities for expanding the agricultural area

Growth in yields has slowed significantly

Producing more with less is a key challenge for the future

Food and Agriculture Organization of the United Nations

Source: http://www.fao.org/publications/fofa/en/

Food and Agriculture Organization of the United Nations (FAO). The future of food and agriculture. trends and challenges, 2017

Precision Agriculture and Big Data

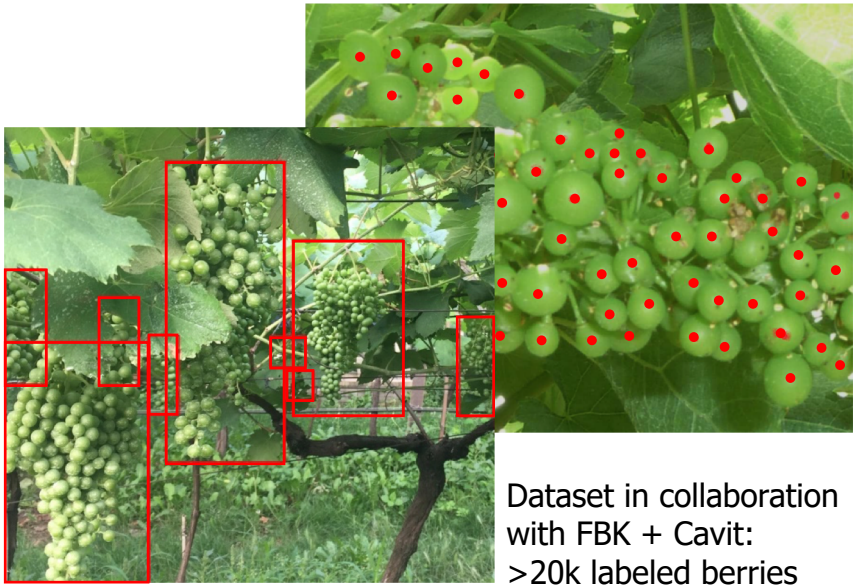
Big Data 1: pre-packaging quality control

Big Data 2: In-field machine learning

Melinda sceglie Cherry Vision 2 di Unitec: cresce l'efficienza e qualità garantita per i consumatori di ciliegie

19 Luglio 2016

High throughput data from QC with Spectroscopy



Dataset in collaboration with FBK + Cavit:
>20k labeled berries
> 200 labeled bunches

Source: http://www.freshplaza.it/article/4083881/melinda-sceglie-cherry-vision-di-unitec-cresce-l-efficienza-e-qualita-garantita-per-i-consumatori-di-ciliegie/

FONDAZIONE BRUNO KESSLER

CAVIT TRENTO

Context

Scholarship: Jan 1 – Dec 31

FONDAZIONE BRUNO KESSLER

MPBA
PREDICTIVE MODELS FOR BIOMEDICINE & ENVIRONMENT

Fondazione Bruno Kessler (FBK)

Predictive Models for Biomedicine & Environment, Trento

Activities

Cloud-based web platform development

Deep learning for agriculture

Education

Smart Agri Scenario

why | Farmers have no easy access to AI technologies

how | Take advantage of what technology they already use

what | Adalitix: cloud based web platform for Agricultural Data Analytics

Adalitix: Agricultural Data Analytics

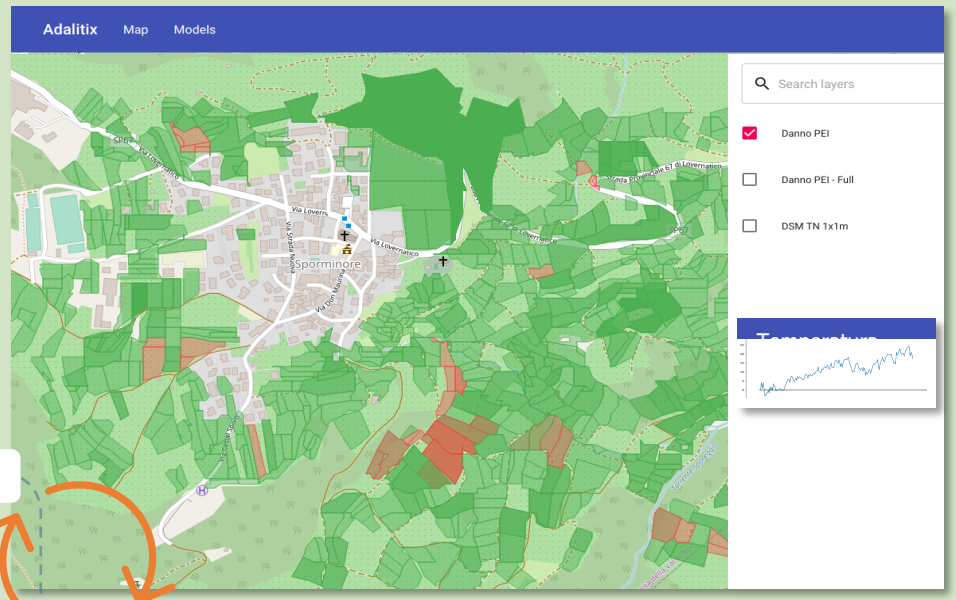
Environmental Big Data

IoT devices / ML on the Edge

Real time weather/radar data

Data Ingestion

Risk predictive model (e.g. frost)



Machine Learning as a Service

Clipper + Docker

PyTorch Tensorflow

Sciikit-learn

Expert-in-the-loop

Stack Tecnologico WebGIS

React Django GeoServer

Export a CKAN data management framework

How It Works

Web Application

GeoServer | geospatial data sharing server

Django | python web server for routing and auth

React | component-based & declarative framework

AI Engine

Clipper | a low-latency prediction serving system for ML

Docker | container system for analysis base images

Kubernetes | container orchestration for production systems

Data Storage

PostGIS | spatial database based on PostgreSQL

CKAN | open source data platform to make data accessible

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Expert-in-the-loop & ML-as-a-Service

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data accessible to other CKAN for institutions and researchers

New models and pipelines can be uploaded

DL for Grape Yield Prediction

Convolutional Neural Network (CNN)
Dilated Kernel, CSRNet (Li, 2017)

Deep Learning:
Crowd counting density map CNN for berries count

Image acquisition
using smartphones or other (automatic) acquisition systems

Training:
- 2 ore in Azure Cloud w/ PyTorch
- NCv2: 2 GPU x 12GB RAM
- CSRNet: 130k parameters to learn

Dataset

Close to harvest time

Manually annotated

Grapes

Variety: Teroldego

Annotations: 17 mid distance images, 18k berries

Shooting distance: 1-1.5 meters

Resolution: 2448×3268

~2 months before harvesting

Manually annotated

Cavit (collected by experts)

7 different varieties

Annotations: 64 closed up images, 17k berries

Shooting distance: 0.3 meters

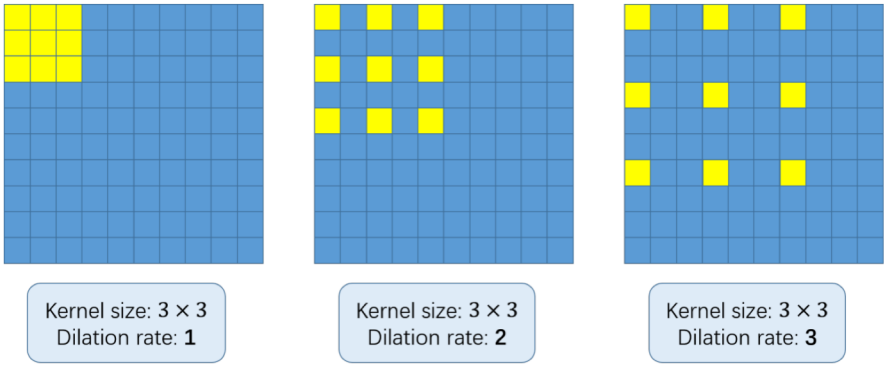
Resolution: 3024×4032, 1200×1600

Dilated Convolutions

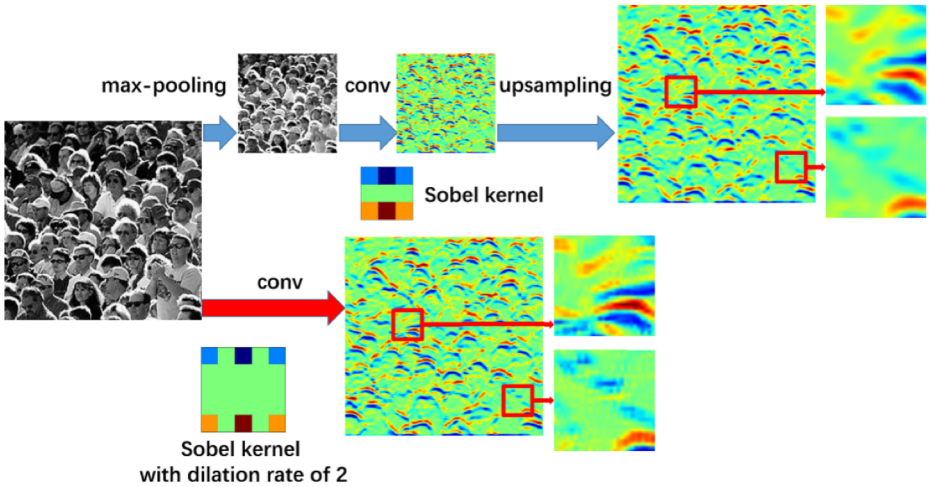
Sparse kernels

1. Enlarges the receptive fields
2. Maintain the same number of parameters
3. Aggregate multi scale information
4. Keep the same resolution

Results contain more detailed information



Li *et al.* 2018



Results

		n	MAE	MAE (%)	MSE
5-fold CV	Per Image	20.4	13.66 ± 4.70	11.16% ± 2.70%	18.33 ± 6.33
	Overall	2670.6	56.48 ± 60.08	2.13% ± 1.97%	
Test	Per Image	26	13.25	10.32%	16.07
	Overall	3653	10.65	0.29%	

Table 5: Application of CSRNet on CR1 5-fold CV and test sets. The N column refer to the average number of images and berries per fold and in the test set.

The interest is in the aggregated count, not the single image one!

CSRNet training details

Adam for 200 epochs
learning rate set to 1e-5
5-fold cross validation

DL for Berry Quality Estimation - Fruitipy

Objective: to estimate grape quality parameters in non invasive way

Hardware		Software
Low cost NIR spectrometer 3D printed	+	Data Cleaning Preprocessing DL Algorithm

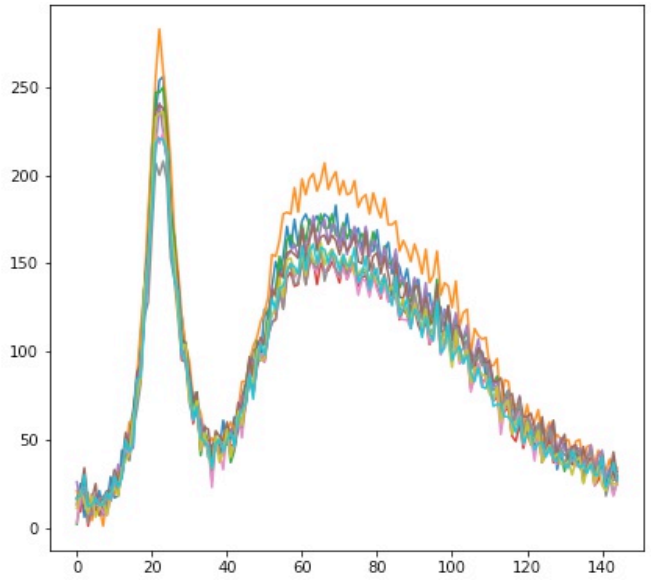
Based on:

Zhang et al., 2019

End-to-end DL approach for spectral data

Ni et al., 2019

Variable weighted-CNN for NIR data



Spectra collection example

From: ad-hoc back-end solution

To: Adalitix based model

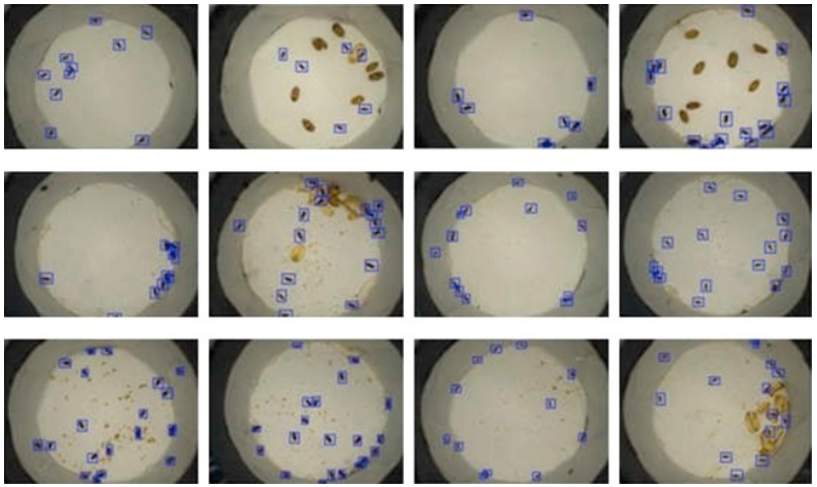
DL for Pest Monitoring - CatchMe

Pest monitoring is performed with 2 tools:

In field traps + microscope

Objective: develop a model to automatically count pests

Challenge: do it with 2 high school students of a Technological Institute



Shen et al., 2018

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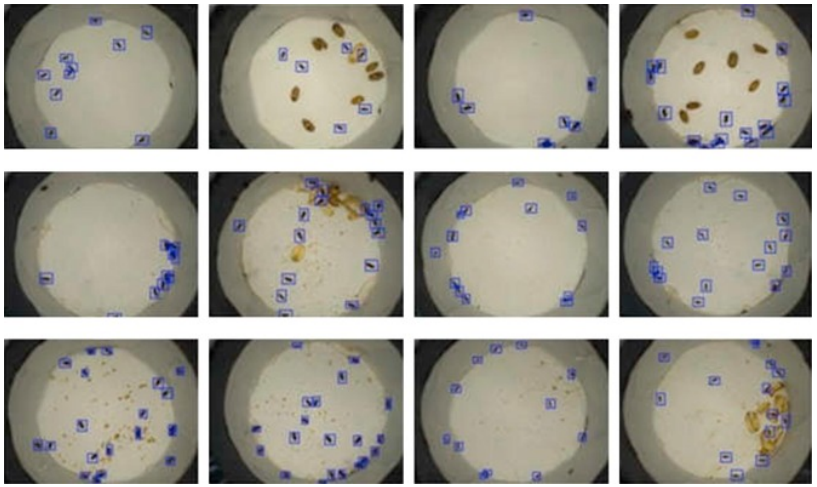

Shen et al., 2018

Seminars:

1. Python (for Data Science)
2. Deep learning basics
3. Object identification models review

Student tasks:

1. Data collection and labeling
2. Data preprocessing
3. Model training and evaluation

Conferences & Presentations

Modeling Crop-Specific Impact of Heat Waves by Deep Learning

AI4Earth Summit @ Microsoft

Seattle, May 14 – 16

Adalitix: Data Analytics nel Web per l'Agricoltura Digitale

Conferenza GARR

Torino, June 4 – 6

Democratizing Smart Farming with AI on LoRa Sensor Networks

TNC19

Tallin, Jun 16 – 20

Future Developments

Adalitix: integration of new frameworks and model

CSRNet: weight estimation from images

Fruitipy: start LoRa experimentations

CatchMe: improve proof of concept with review of different techniques

PEI: model frost risk from environmental and historical big data

Thank you

Luca Coviello

Working Experience

Scientific Developer @ Fondazione Bruno Kessler (2013 - 2016) MPBA Lab: Cesare Furlanello

Experience in **Innovation** and **Entrepreneurship** (StartUps: NewsU, Chameleonline, Billy)

Interested in combining **research** and **innovation** to **agriculture** and **climate changes**

Education

MSc in **Data Science** and **I&E** @ EIT Digital (Madrid, Nice)
thesis in **Deep Learning applied to Smart Agriculture** + **I&E** minor

BSc in **Computer Science** @ UniTN, Intern @ FBK, Data Science (Prog. Min. Salute)
thesis in **Deep Learning** for Sentiment Analysis and Vaccine Confidence Monitoring