NON-LINEAR PLANT PHENOTYPING PIPELINES:

HOW CAN **STRUCTURAL MODELS** AND **MACHINE LEARNING** CAN HELP US ANALYSE LARGE **PLANT IMAGE DATASETS**

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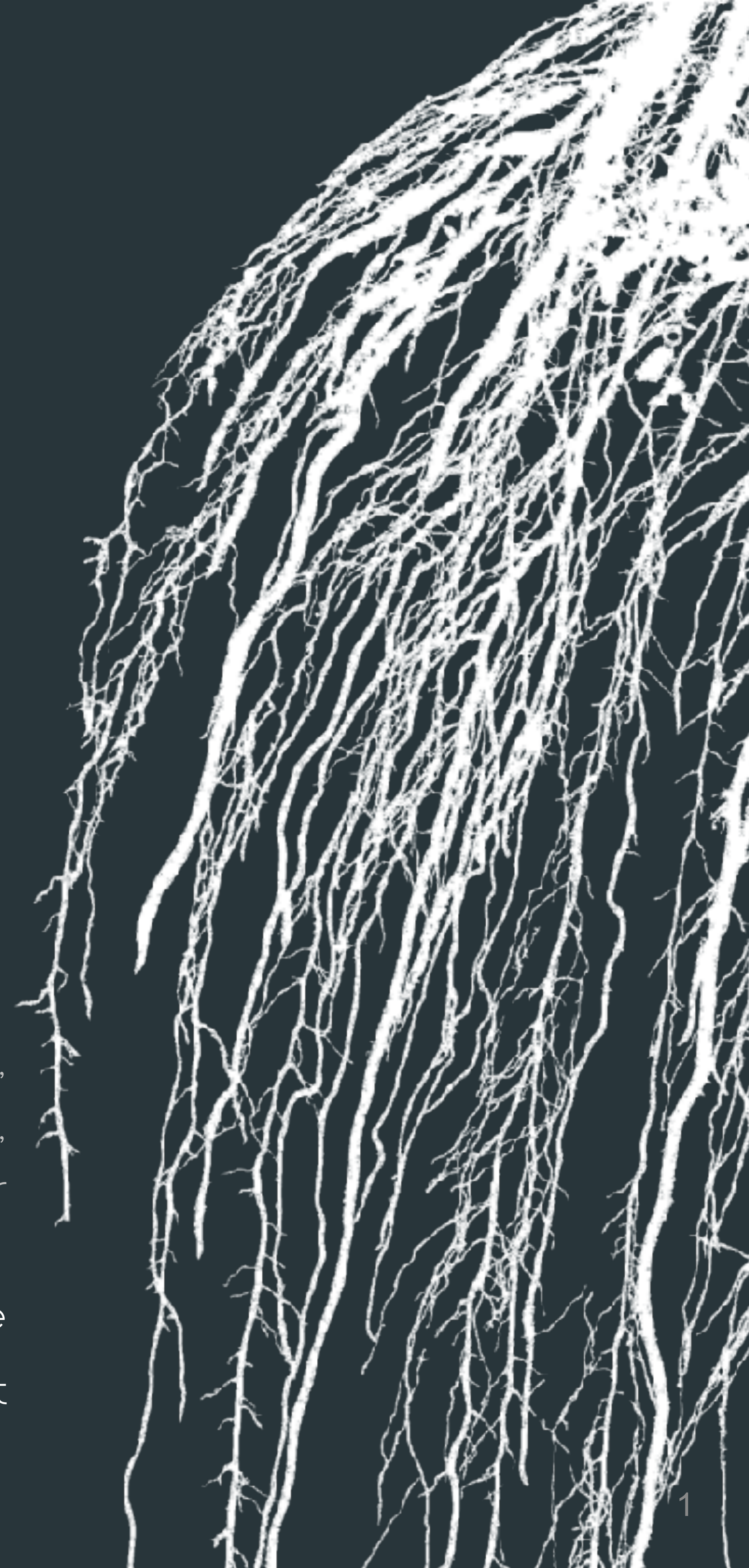
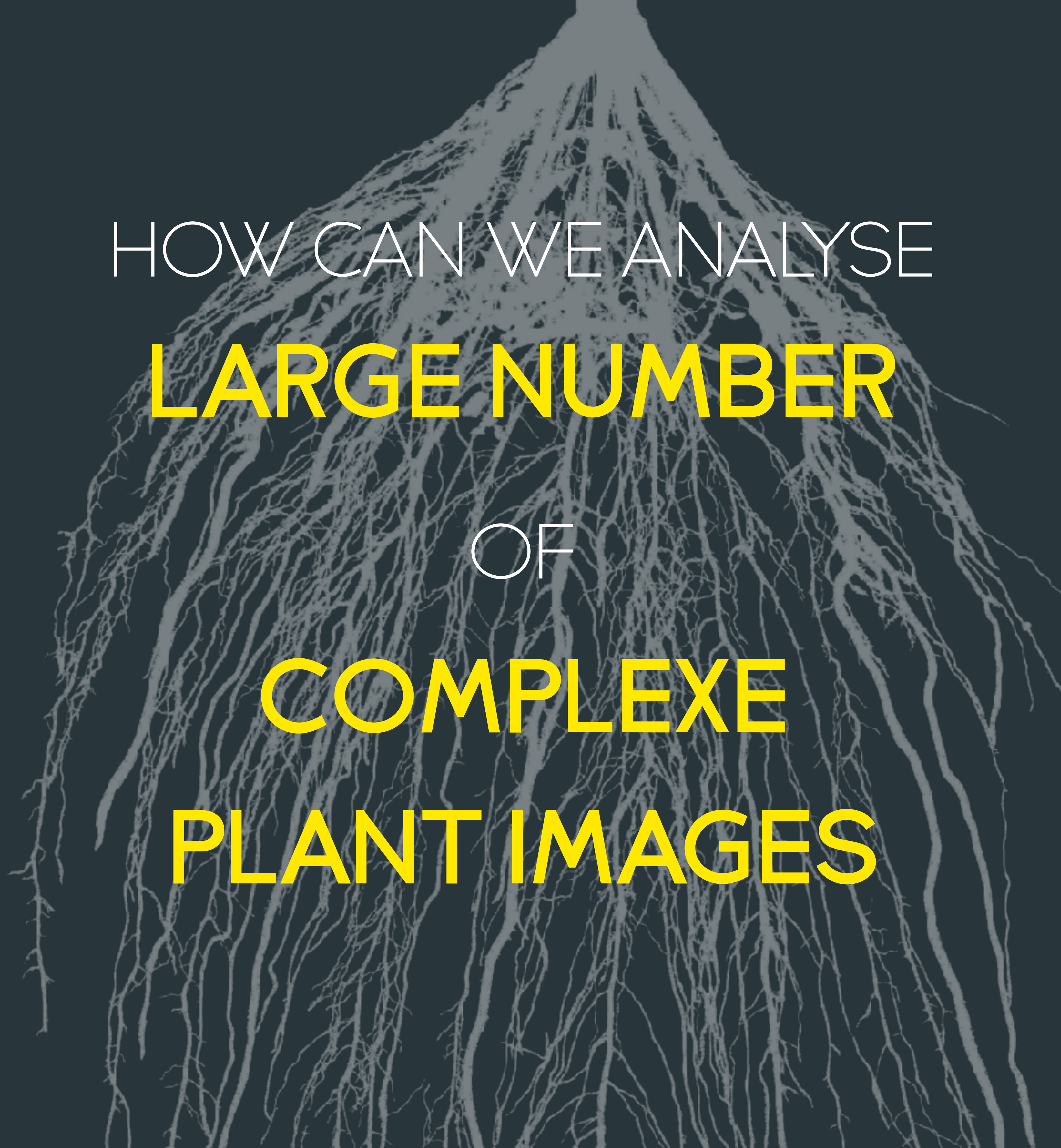
TUCSON, AZ FEBRUARY 14-17

JÜLICH Forschungszentrum

UCL Université catholique de Louvain





HOW CAN WE ANALYSE
LARGE NUMBER
OF
COMPLEXE PLANT IMAGES


IMAGE
ANALYSIS

IMAGE ROOT ANALYSIS MODELS

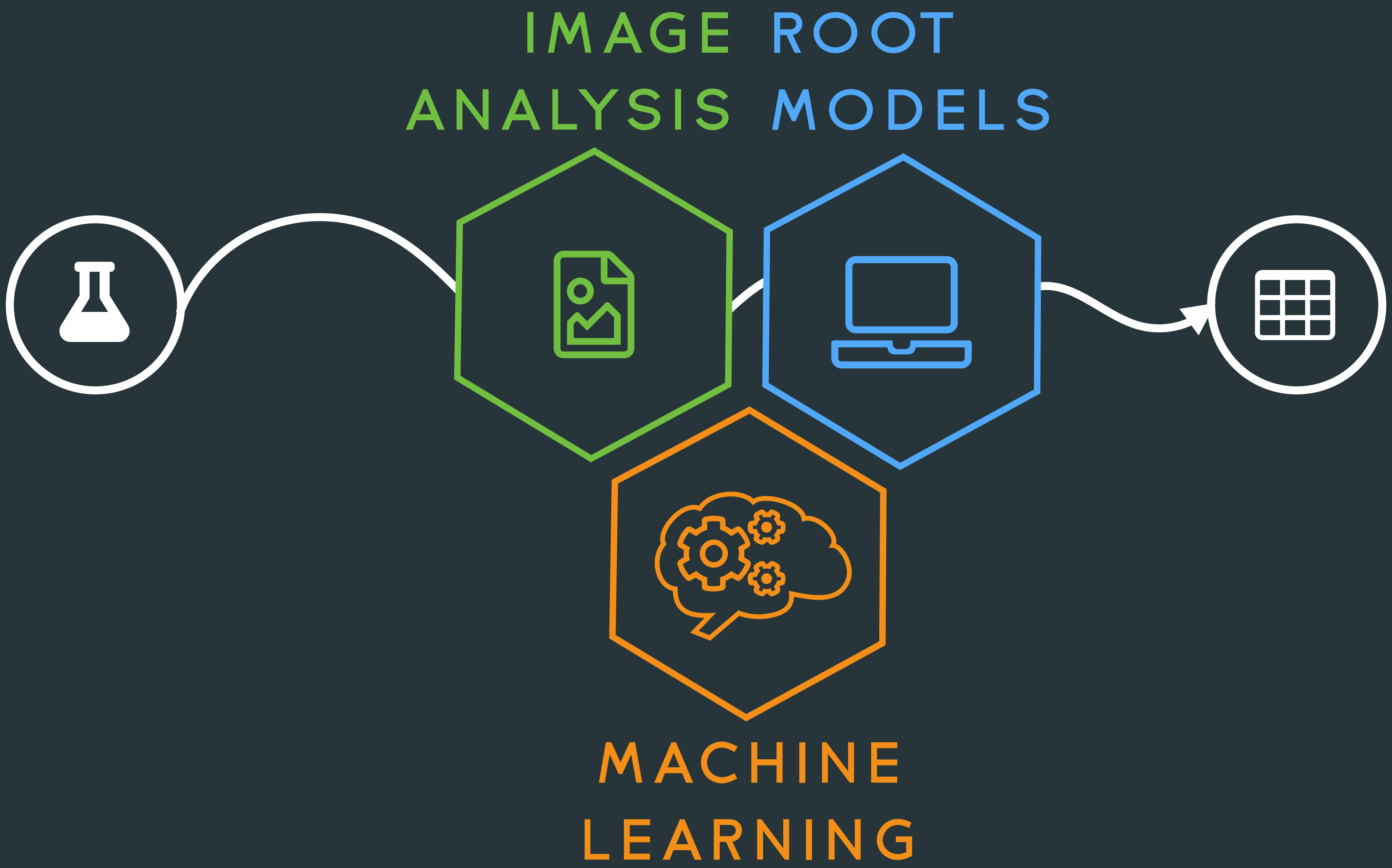
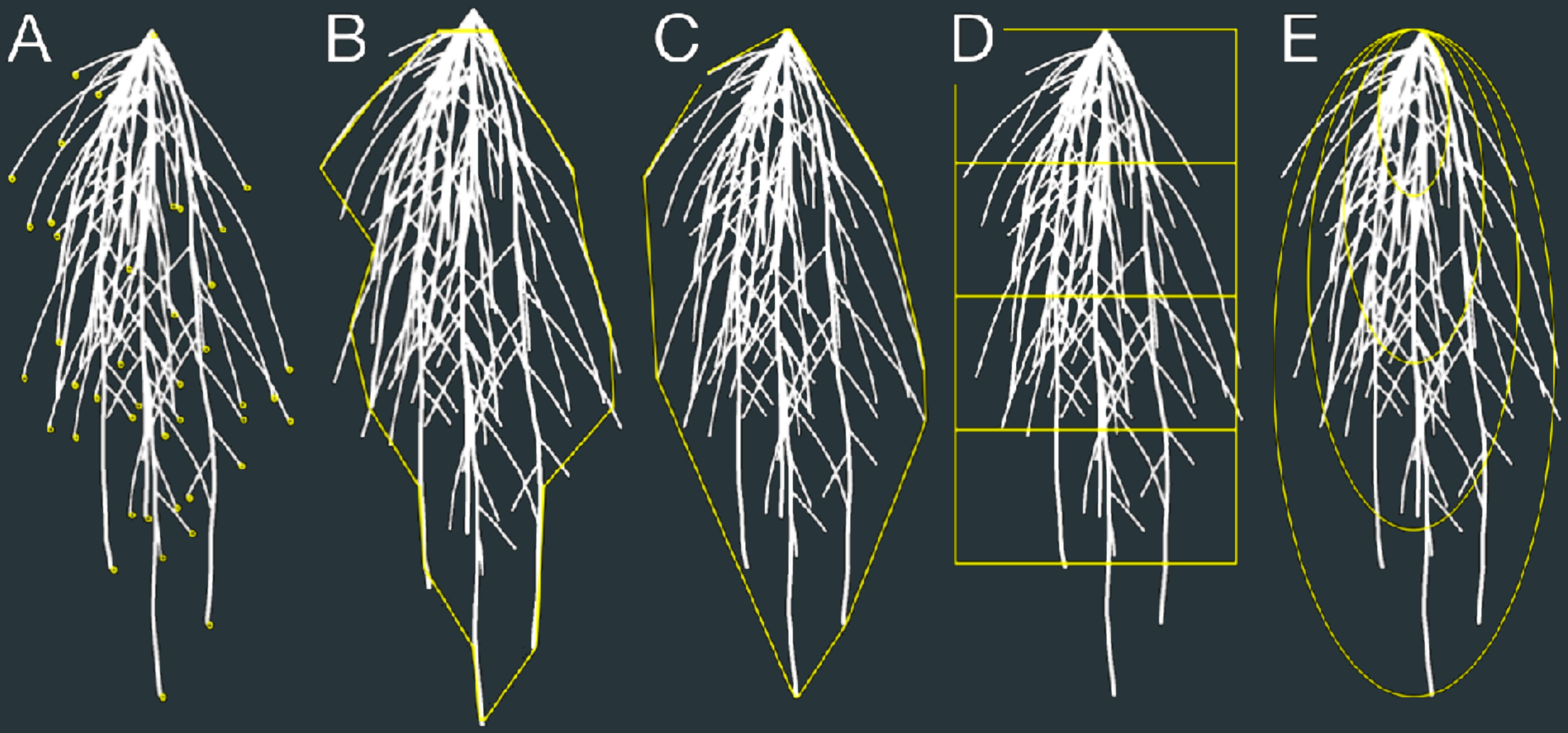


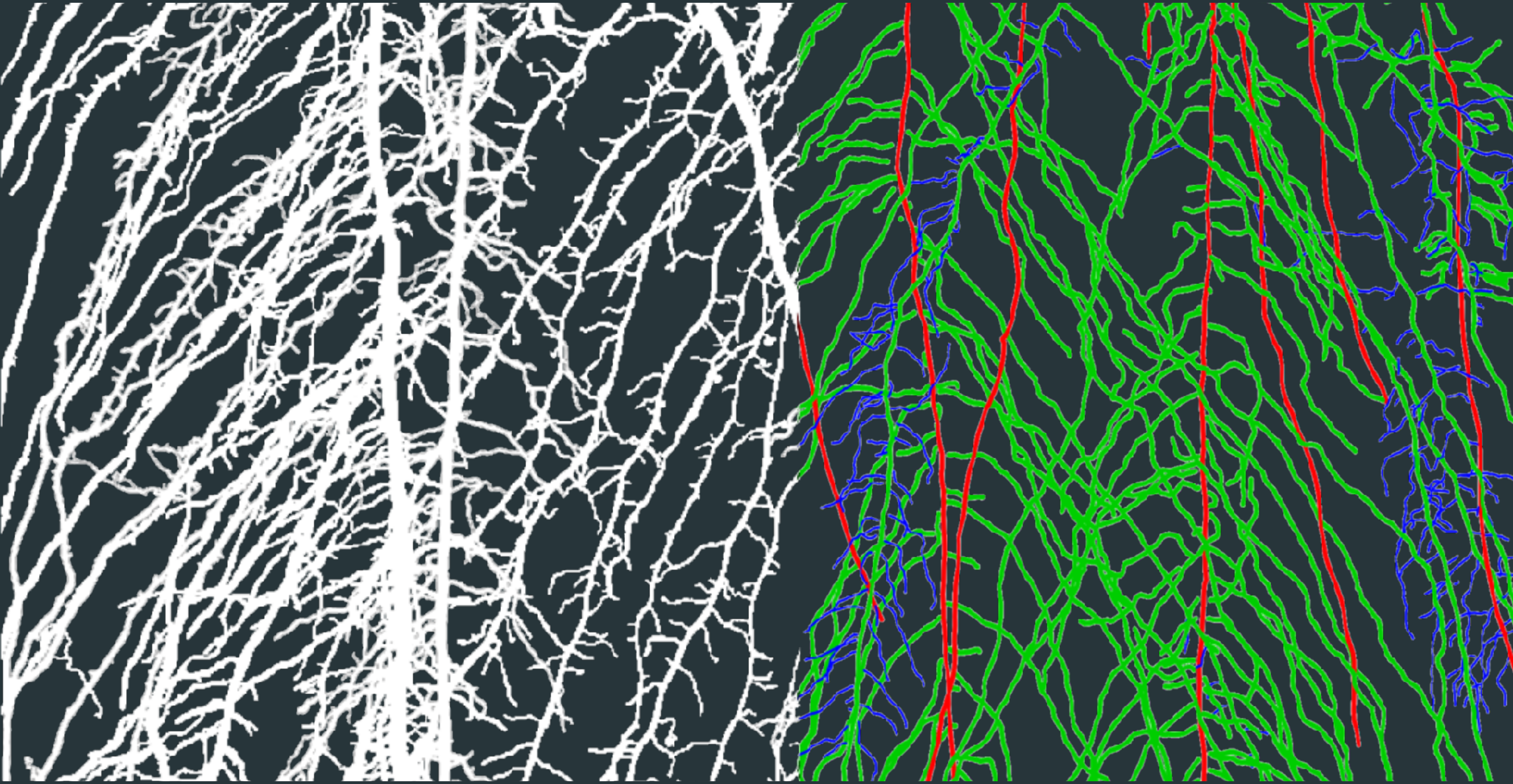
IMAGE ANALYSIS
ROOT MODELS
MACHINE LEARNING

CHEAP VARIABLES = AUTOMATED



DIRT | WINRHIZO | **RIA-J** | GIA-ROOT | ROOTGRAPH

EXPENSIVE VARIABLES = MANUAL



SMARTROOT | DART | **ROOTNAV** | EZ-RHIZO

HOW CAN WE GET THE **BEST OF BOTH** WORLDS?

IMAGE ANALYSIS

ROOT MODELS

MACHINE LEARNING

1

SIMULATED ROOT IMAGE LIBRARY

bit.ly/root-lib

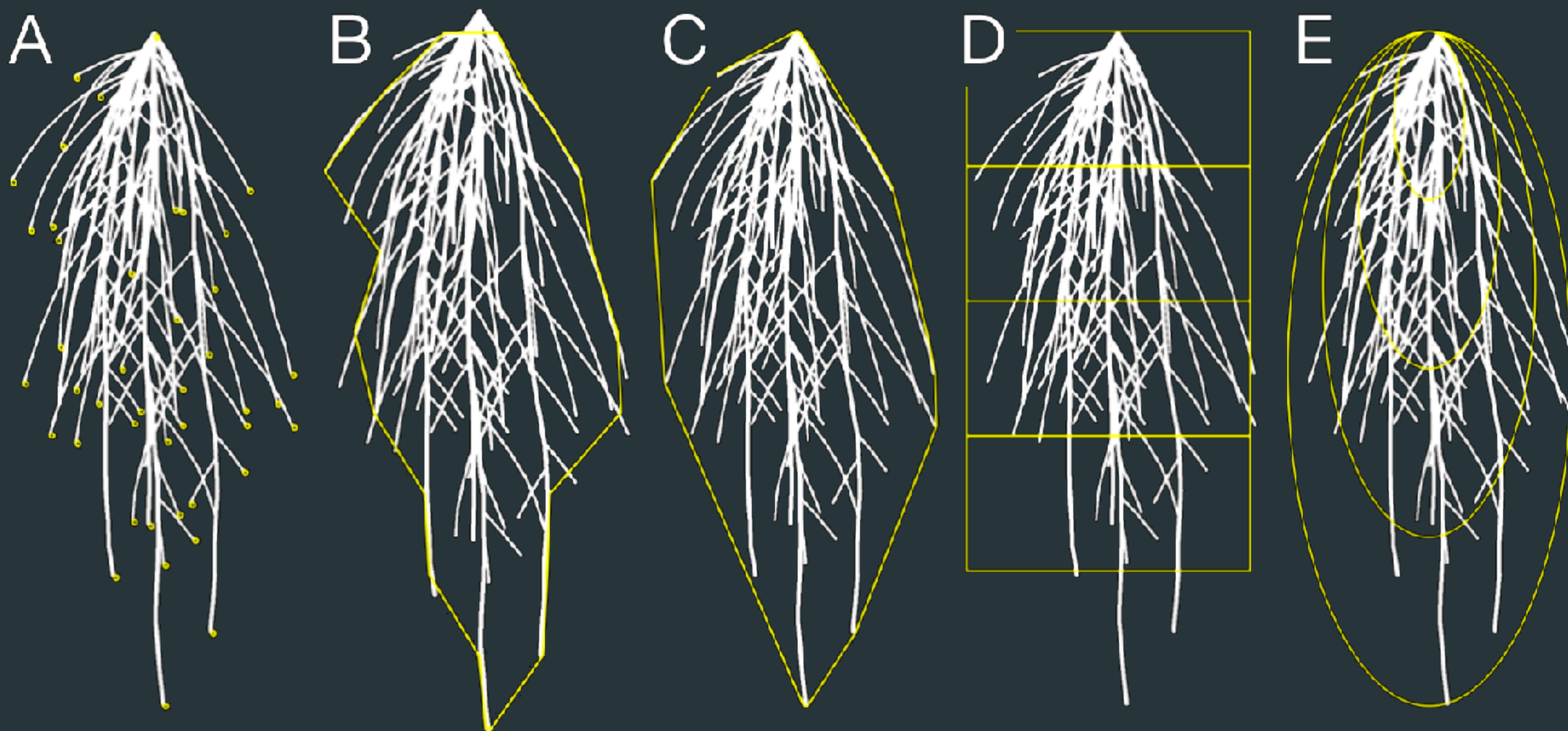
RSML

10.000

CSV

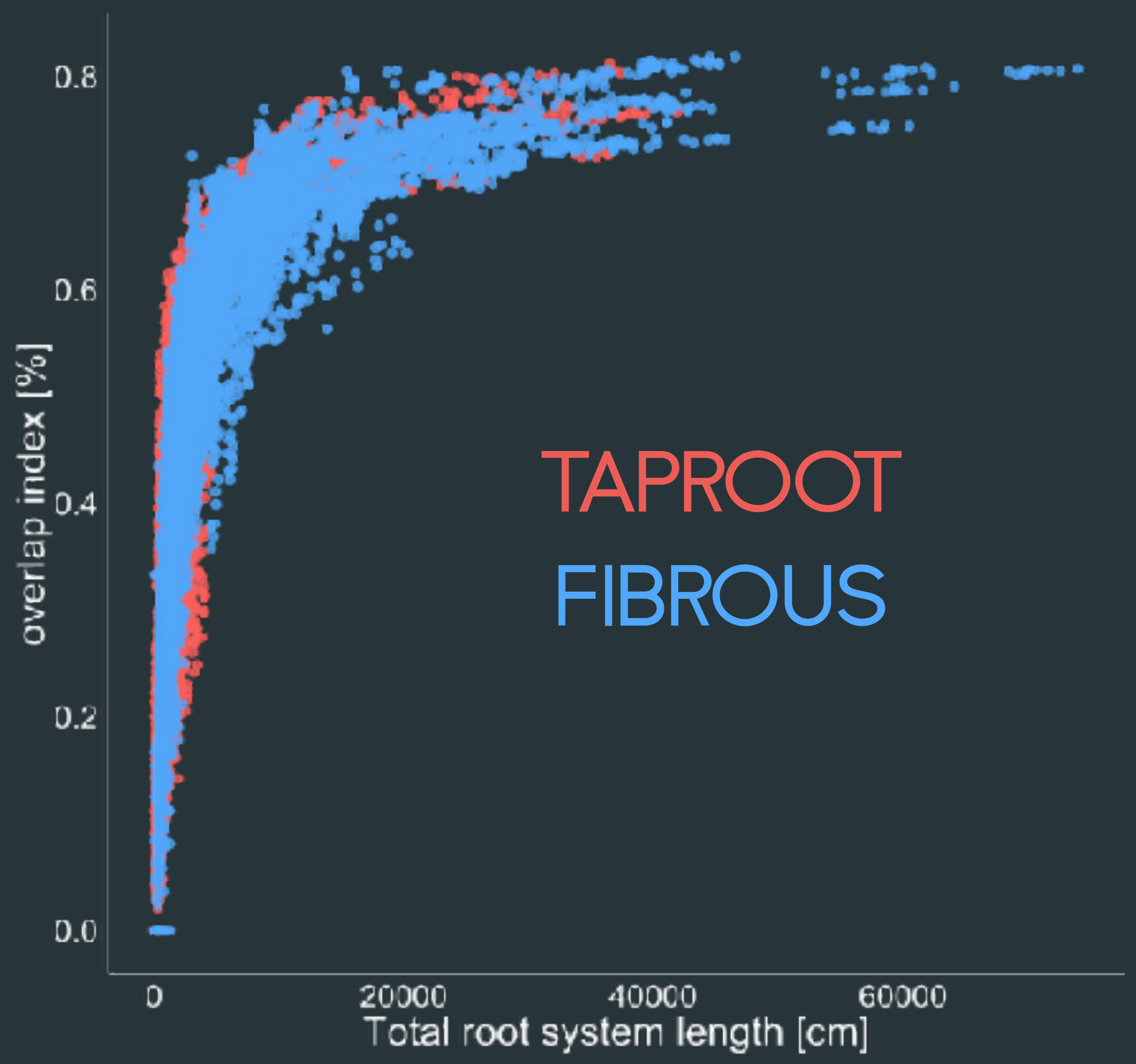
JPG

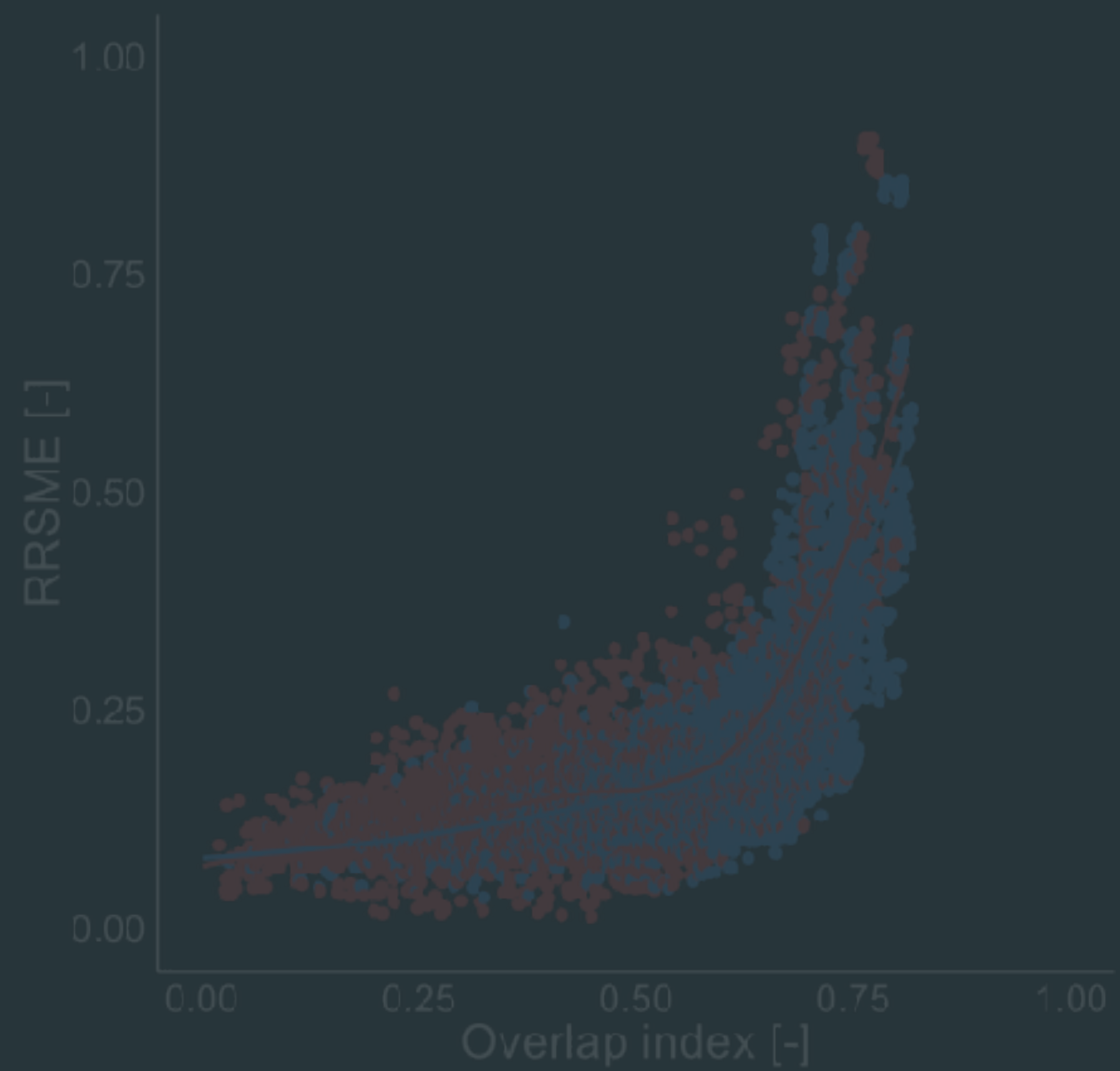
WE EXTRACT **CHEAP VARIABLES**



COMPARED WITH **GROUND-TRUTH**

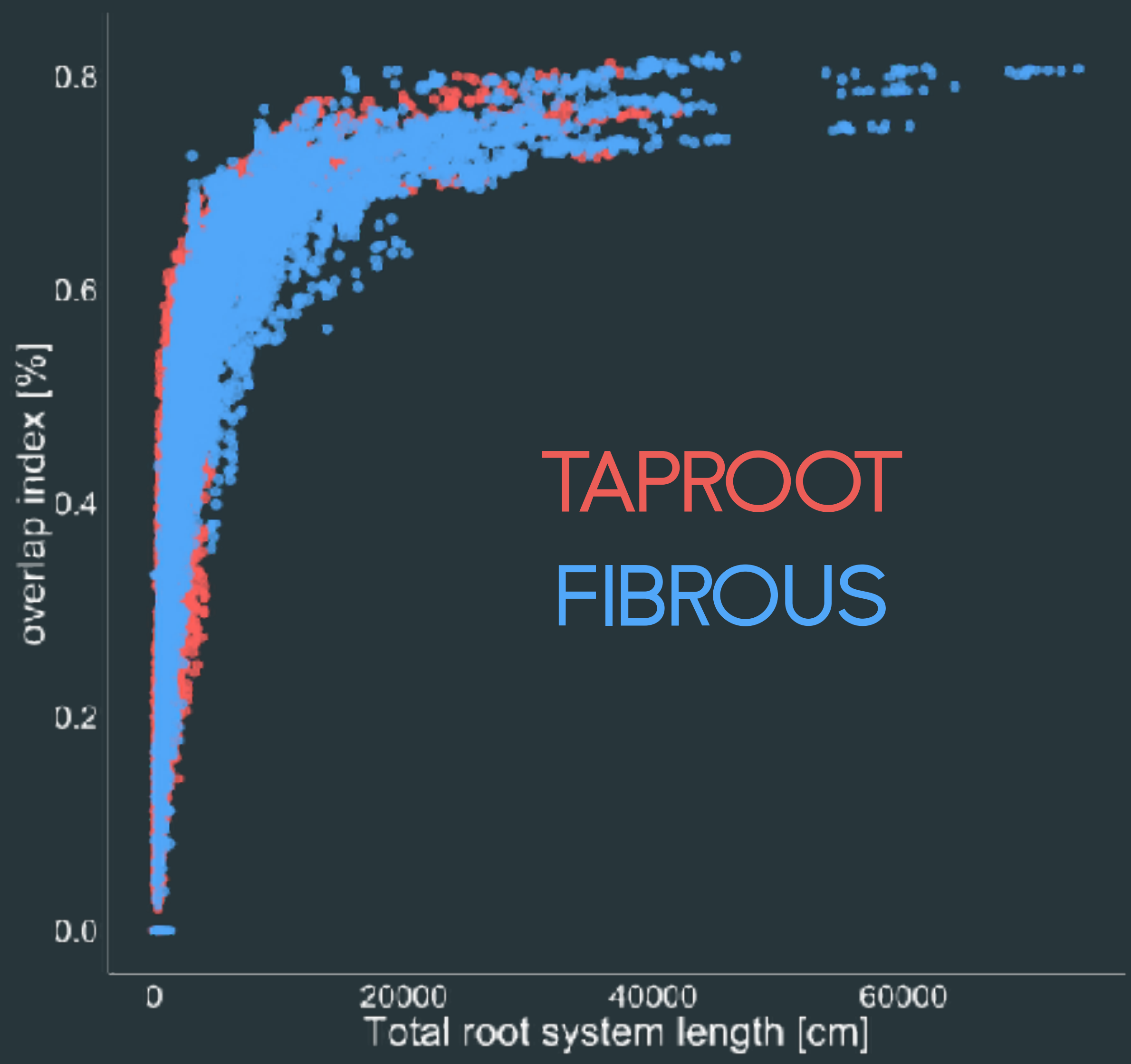
ERROR INCEASES WITH SIZE

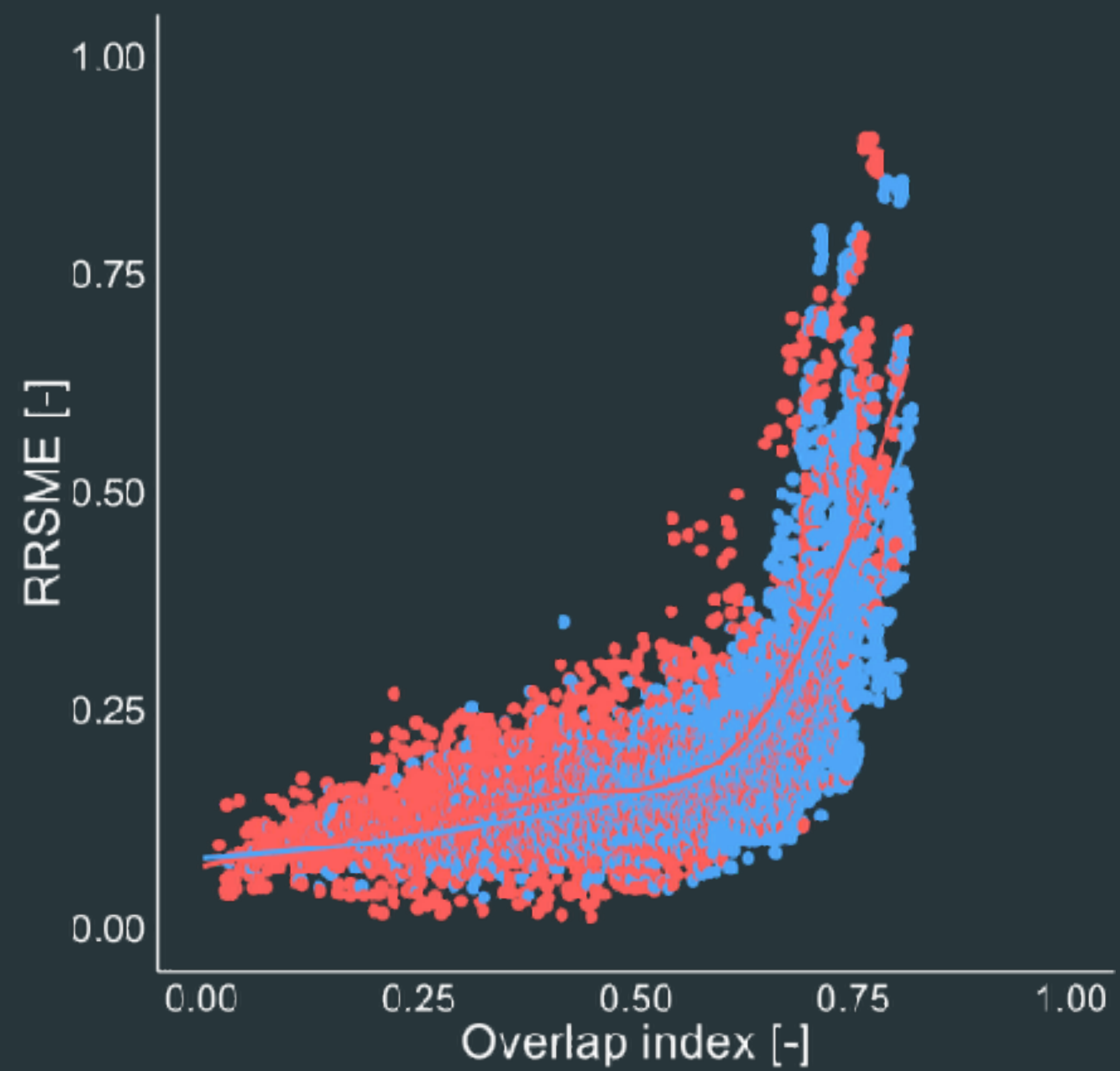




Lobet, Koevoets, Noll et al. 2017
PMID: 28421089

ERROR INCEASES WITH SIZE





Lobet, Koevoets, Noll et al. 2017
PMID: 28421089

IMAGE ANALYSIS

ROOT MODELS

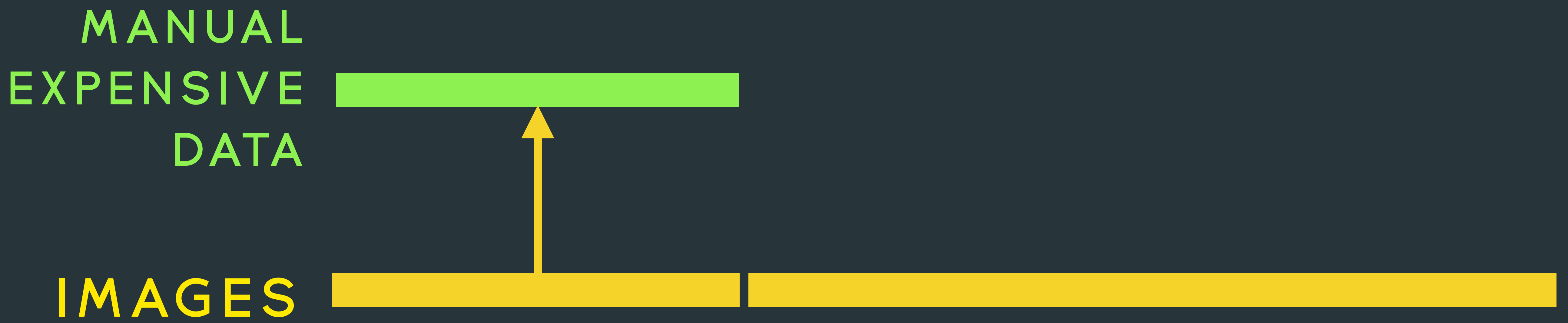
MACHINE LEARNING

2

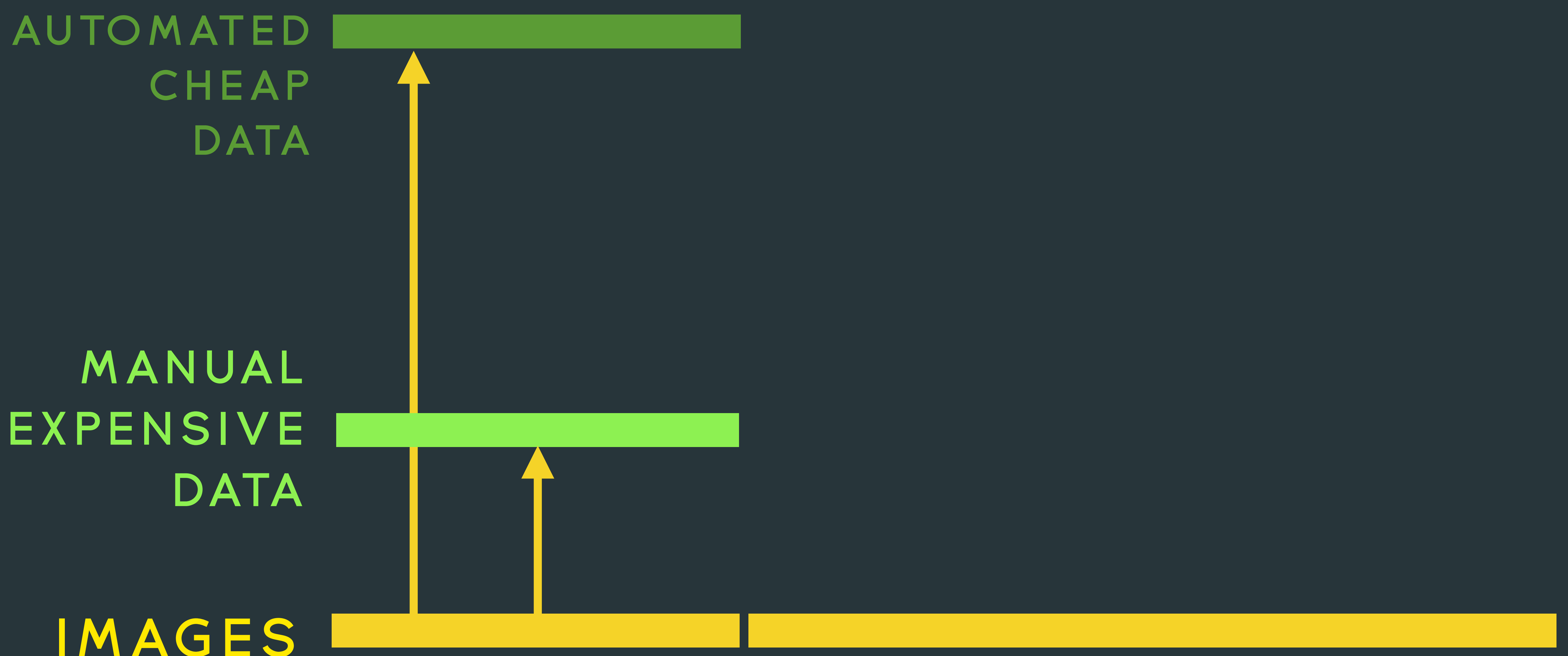
MACHINE LEARNING ASSISTED ANALYSIS

IMAGES

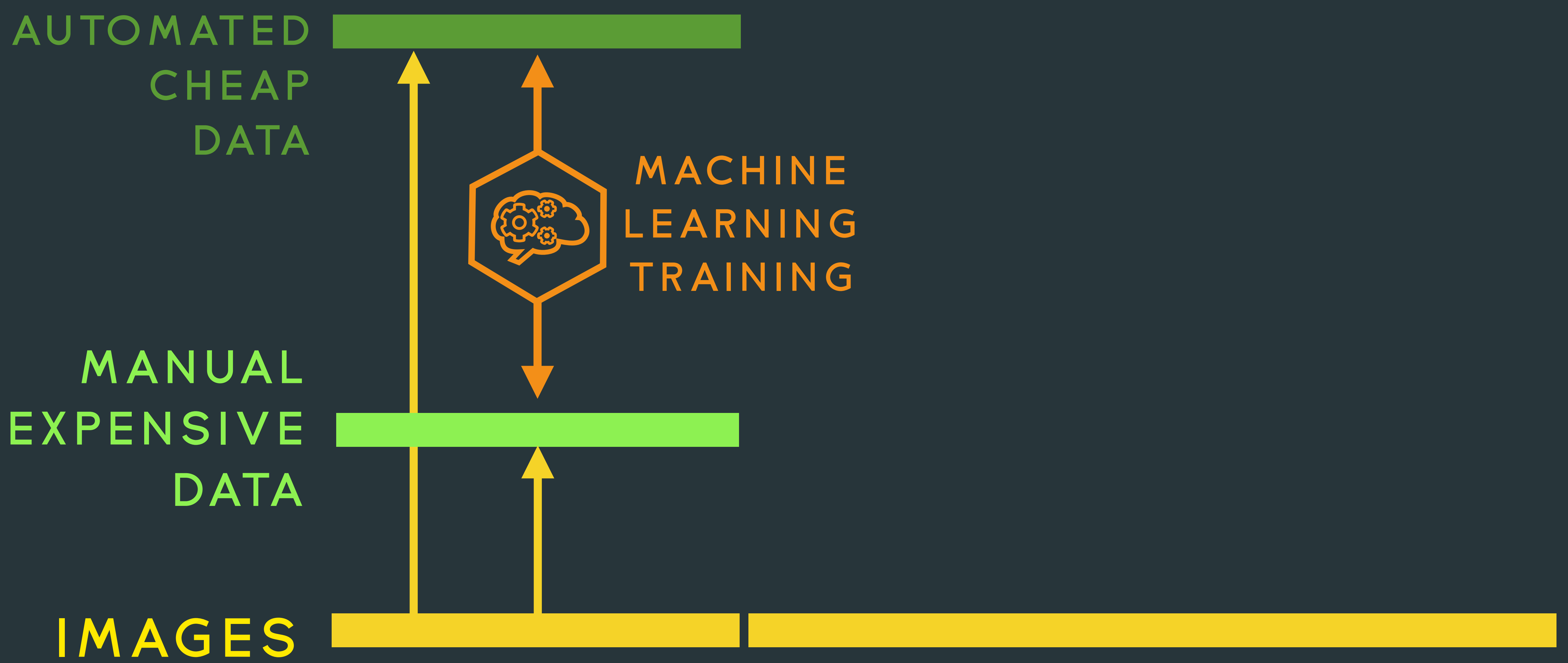
MACHINE LEARNING ASSISTED ANALYSIS



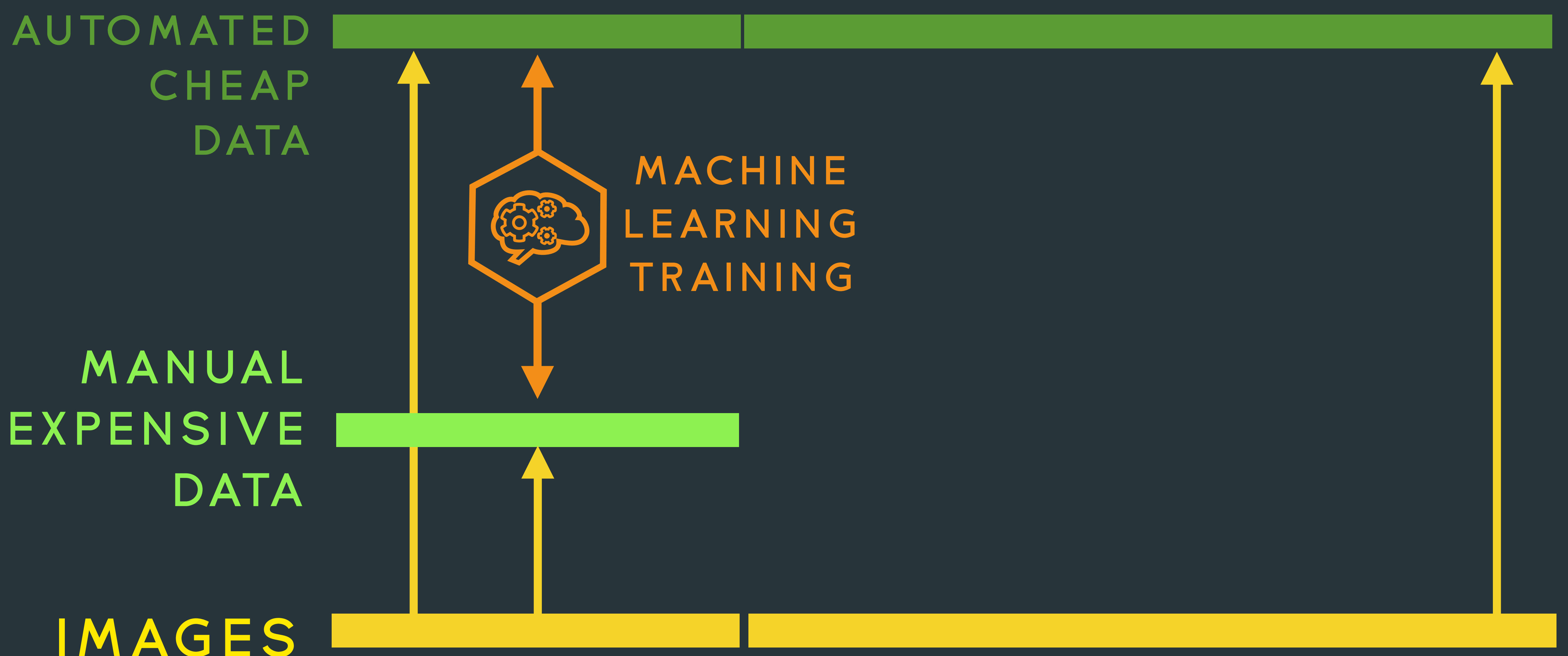
MACHINE LEARNING ASSISTED ANALYSIS



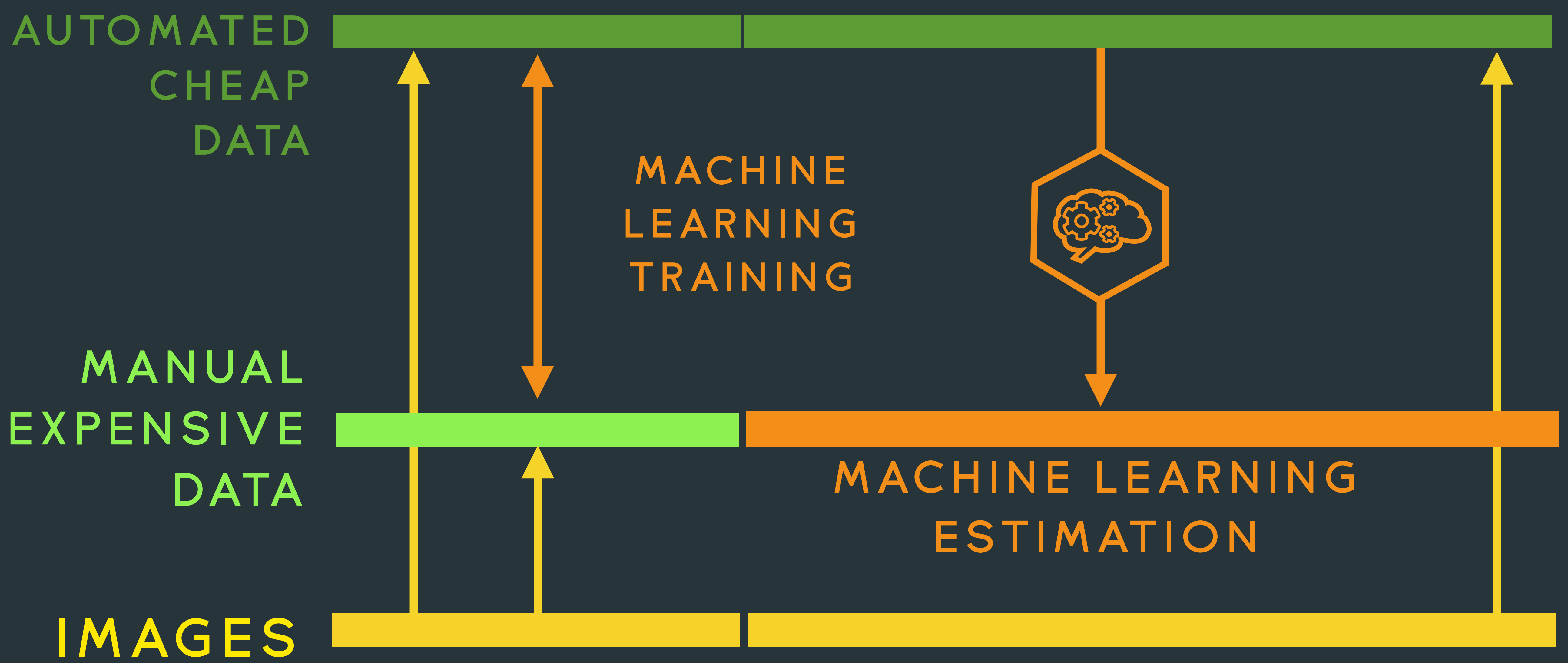
MACHINE LEARNING ASSISTED ANALYSIS



MACHINE LEARNING ASSISTED ANALYSIS

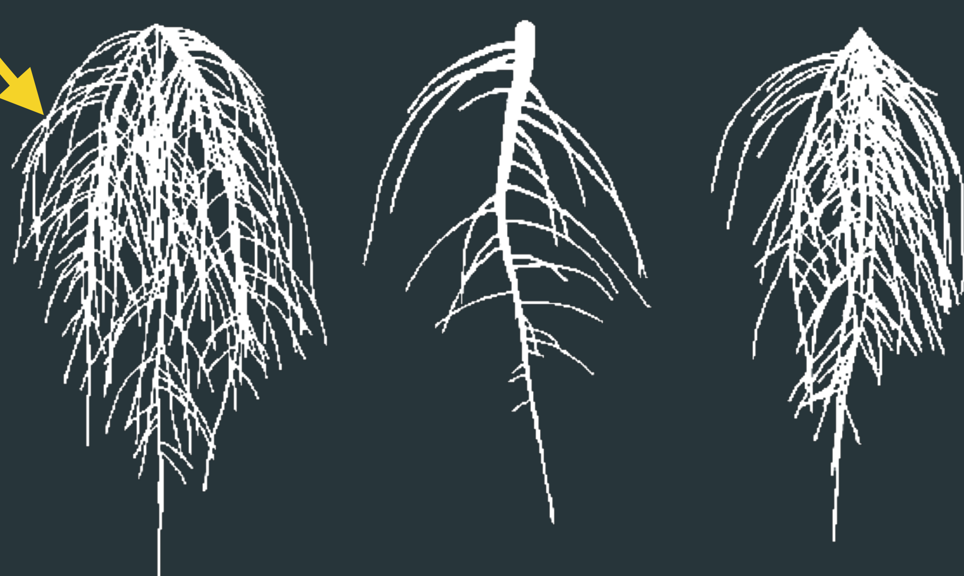


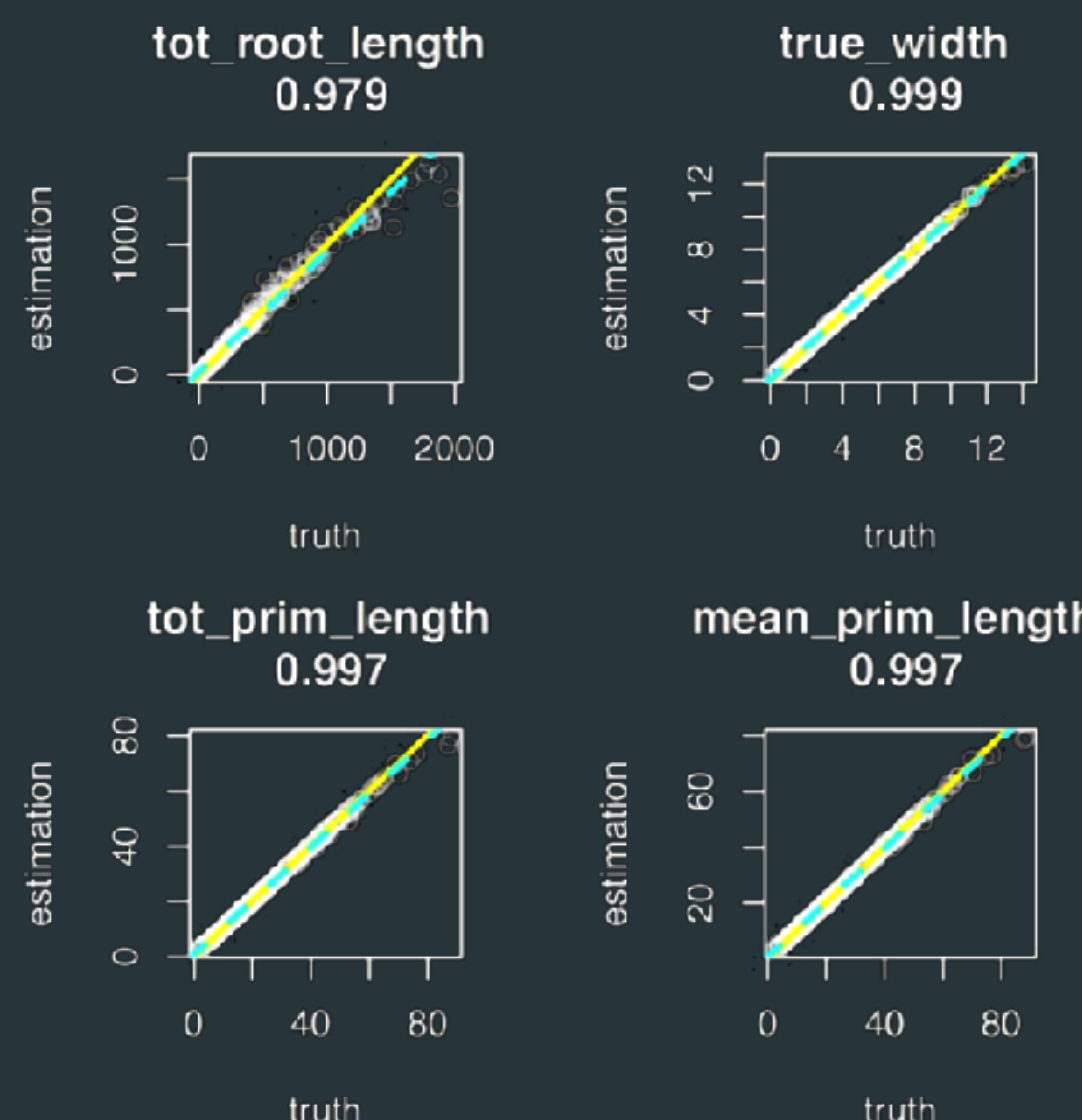
MACHINE LEARNING ASSISTED ANALYSIS



SYNTHETIC DATA

IMAGEJ MACRO	IMAGEJ MACRO
GROUND-TRUTH	MACHINE LEARNING ESTIMATION
5000 IMAGES	5000 IMAGES





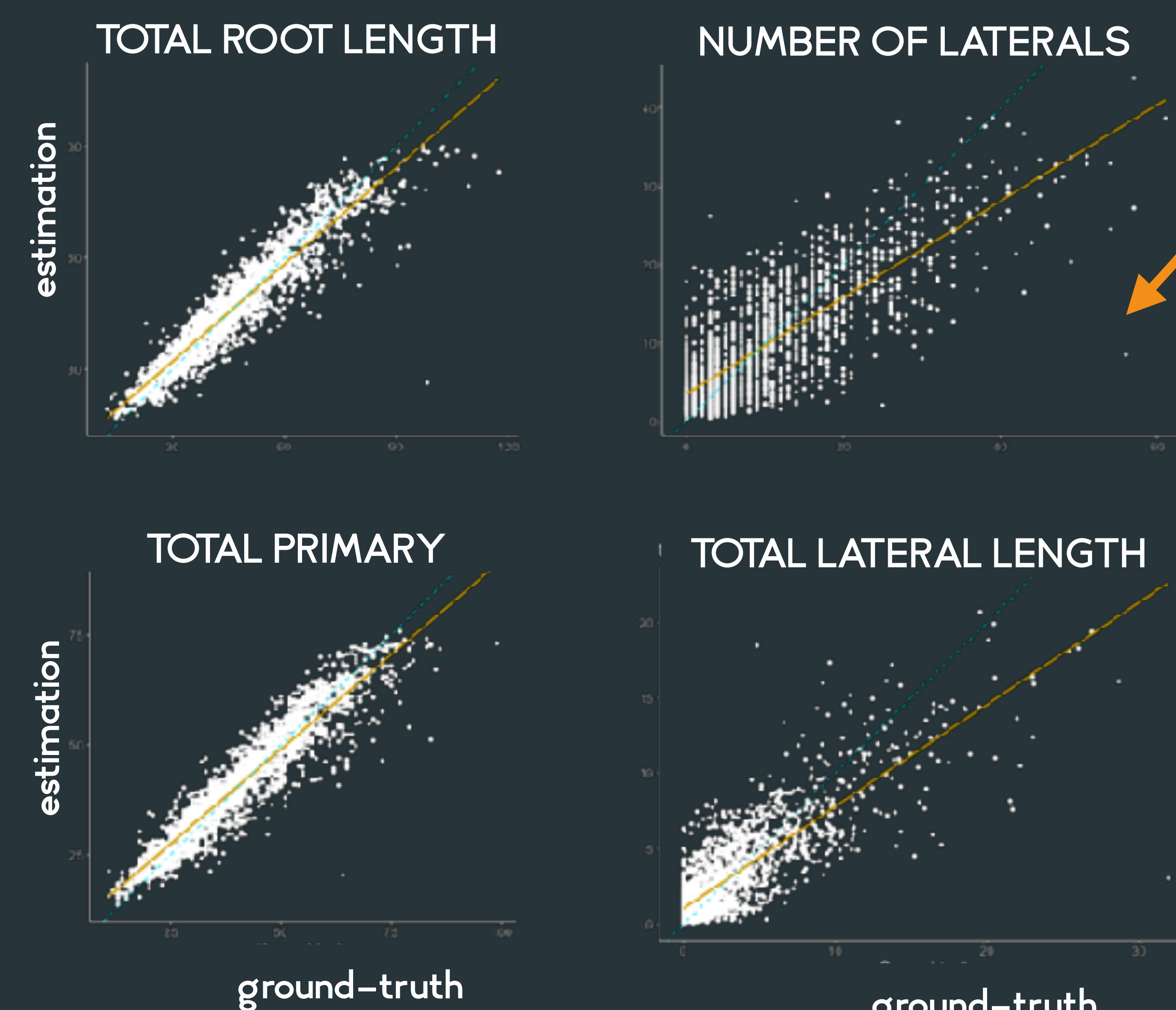
Manuel Noll

Iko Koevoets
@IkoKoevoets

Lobet, Koevoets, Noll et al. 2017.
PMID: 28421089

WHEAT ROOT SYSTEM ARCHITECTURE

IMAGEJ MACRO	IMAGEJ MACRO
ROOTNAV	MACHINE LEARNING ESTIMATION
500 IMAGES	2000 IMAGES



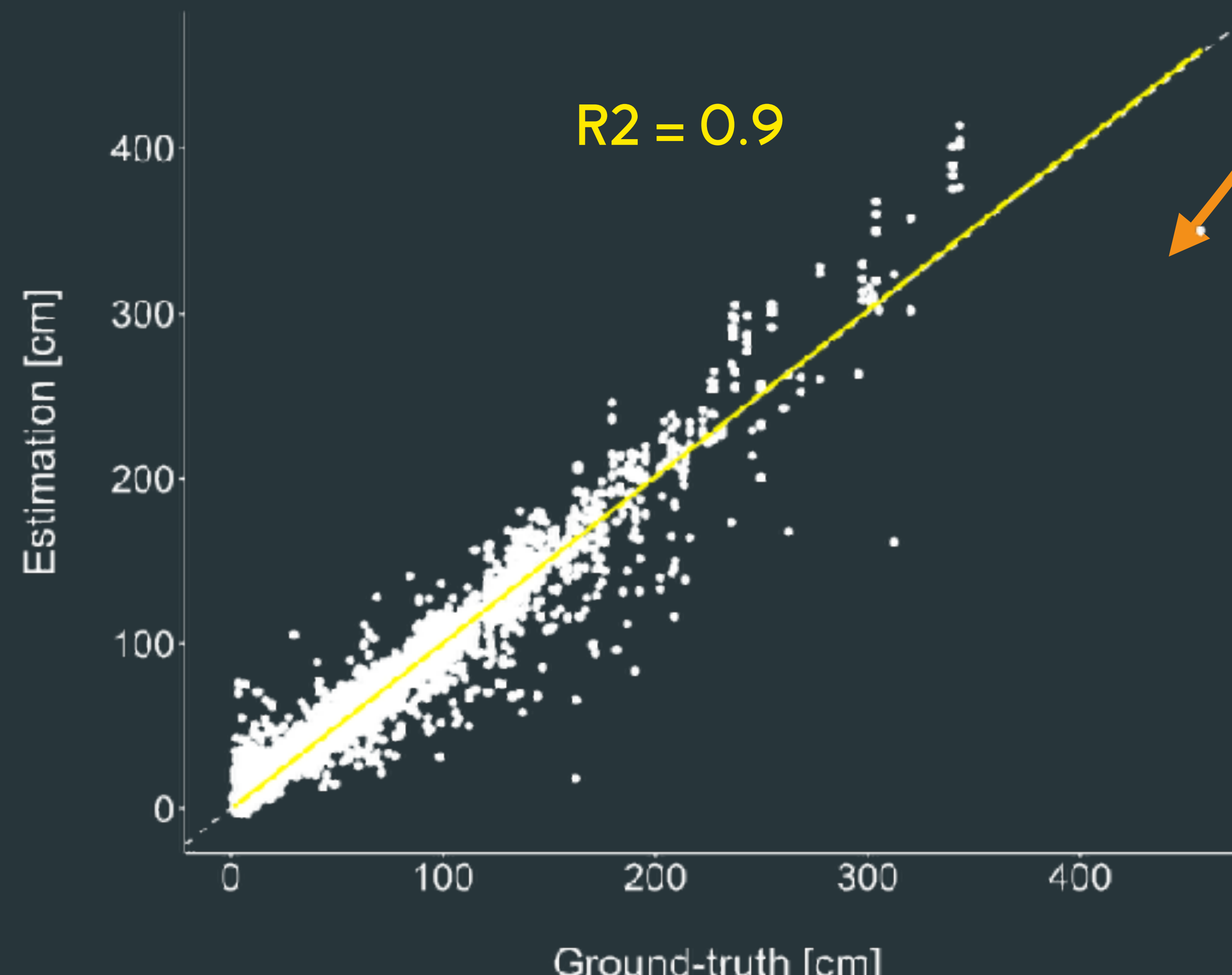
Jonathan Atkinson
@Jon_AAtkinson

Atkinson, Lobet et al. 2017.
PMID: 29020748

MINI RHIZOTRON IMAGES

IMAGEJ MACRO	IMAGEJ MACRO
ROOTFLY	MACHINE LEARNING ESTIMATION
8000 IMAGES	1 000 IMAGES

TOTAL ROOT LENGTH



Shehan Morandage

Mirjam Zorner

R SHINY APP

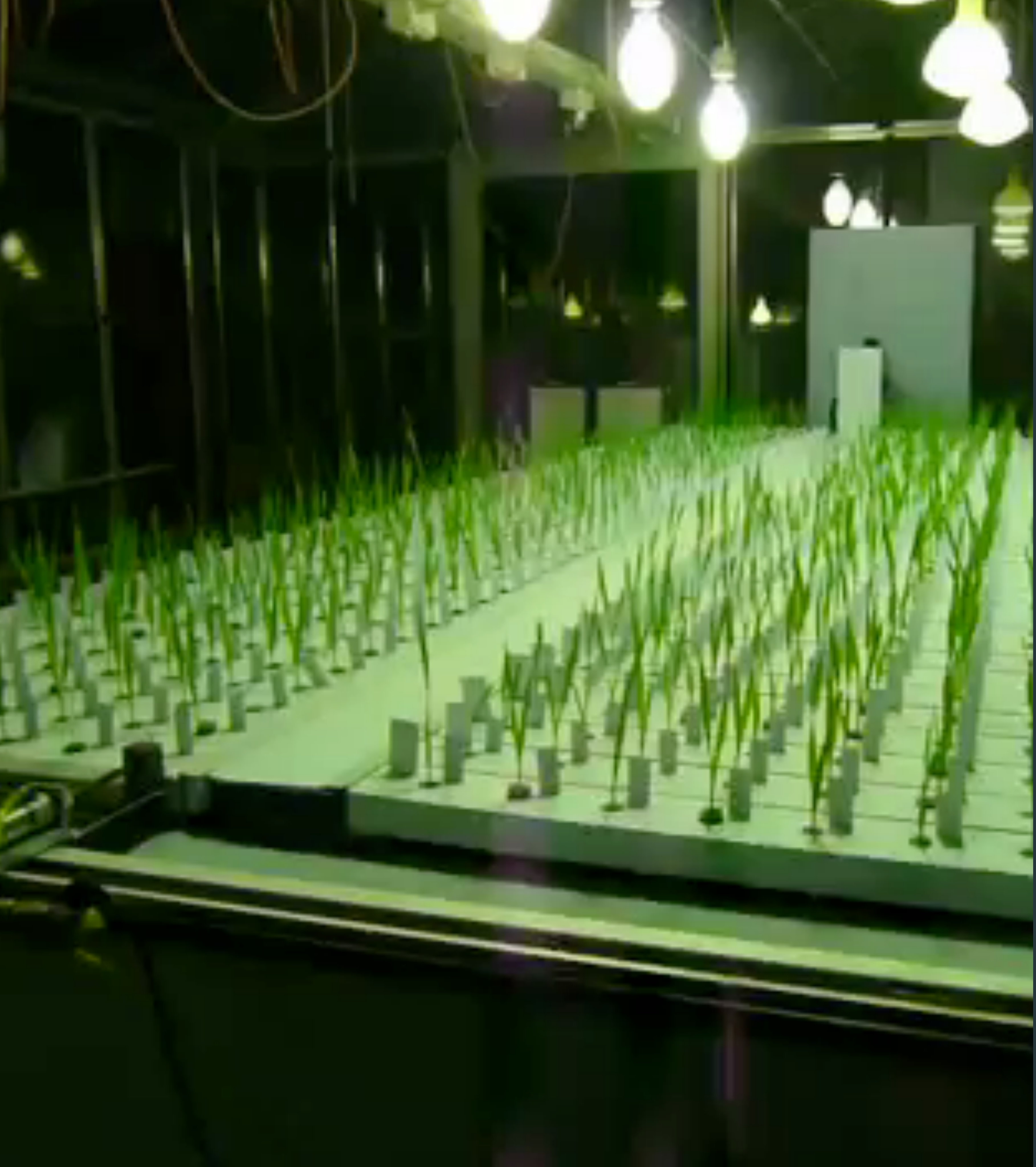
https://plantmodelling.github.io/primal/

3

IMAGE ANALYSIS

ROOT MODELS

MACHINE LEARNING



AEROPONIC PHENOTYPING PLANTFORM

1000 PLANTS

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1 IMAGE / PLANT / 2H

ROOT + SHOOT

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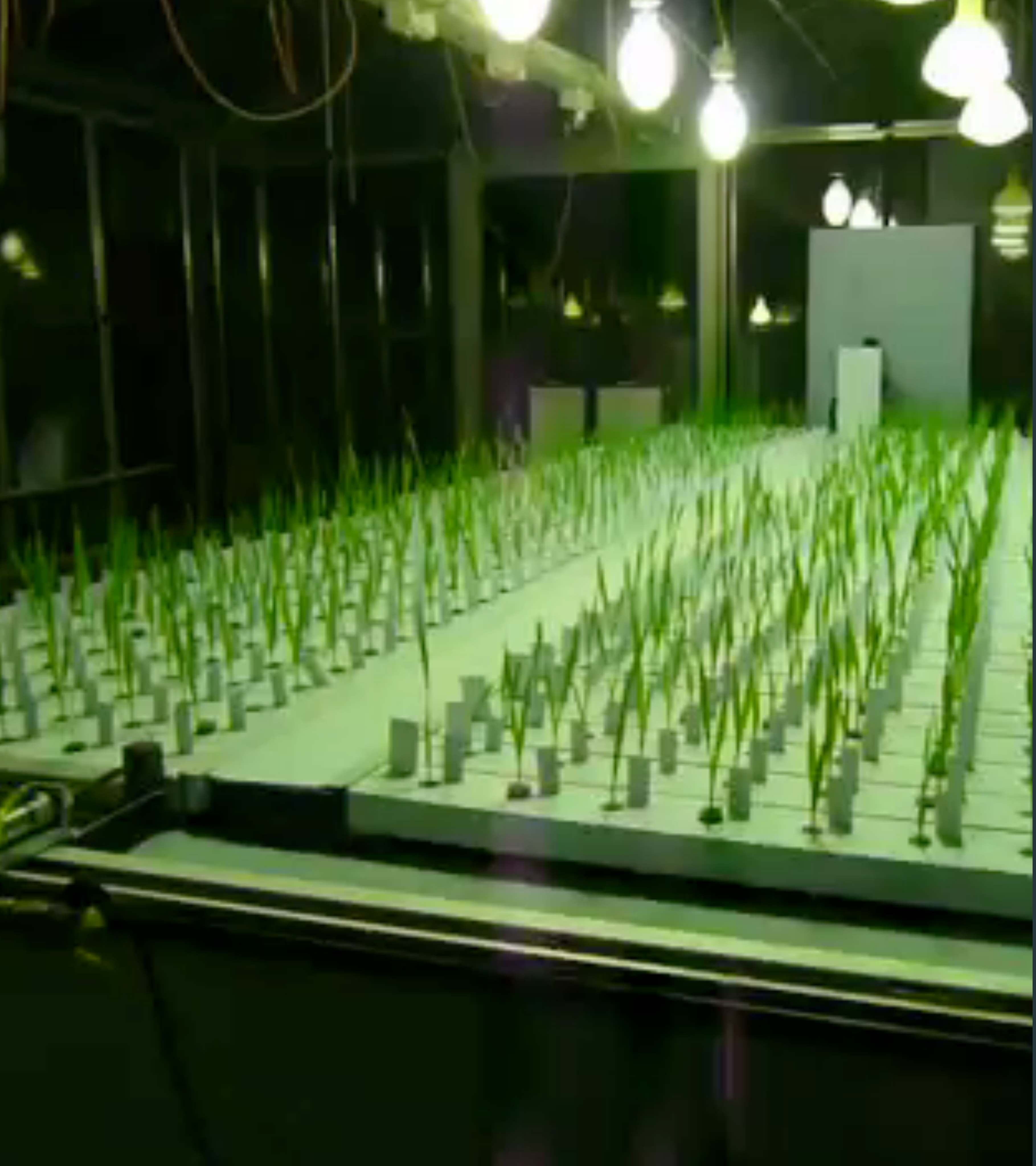
240 000 IMAGES



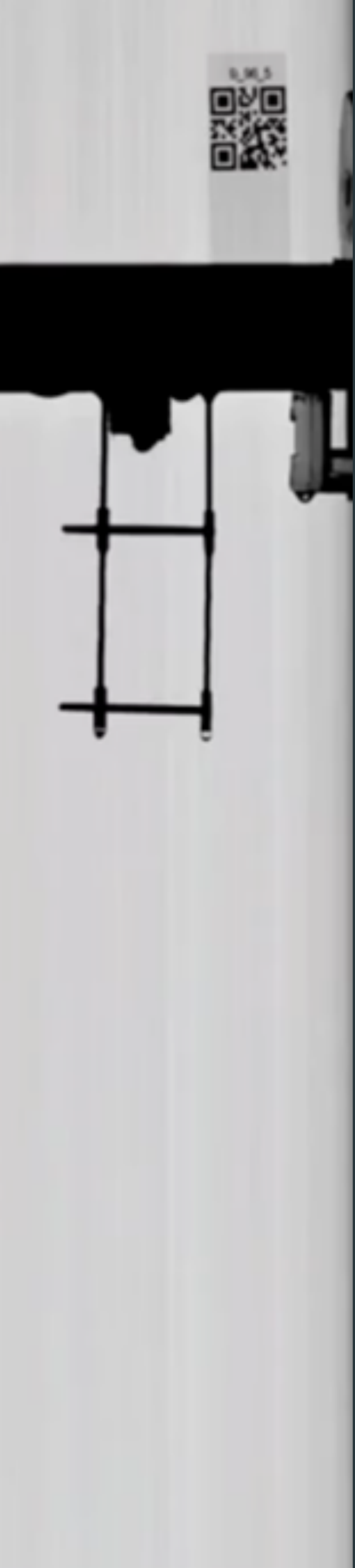
AEROPONIC PHENOTYPING PLANTFORM

1000 PLANTS

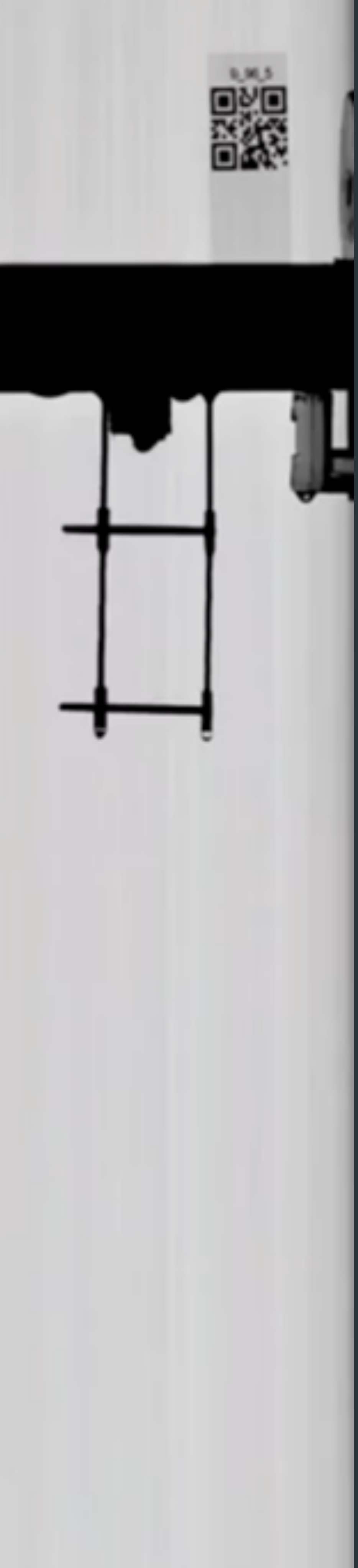
1 IMAGE / PLANT / 2H

ROOT + SHOOT

240 000 IMAGES

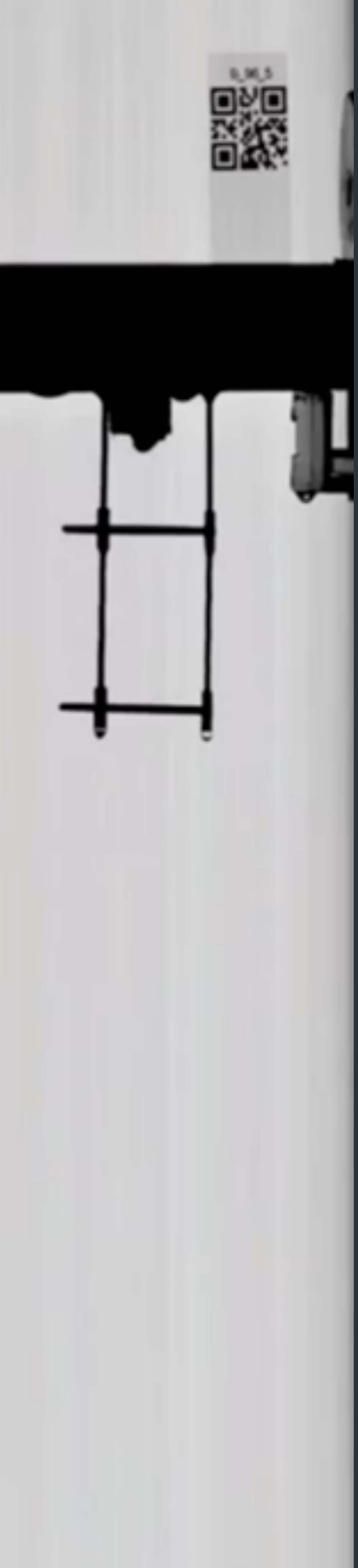


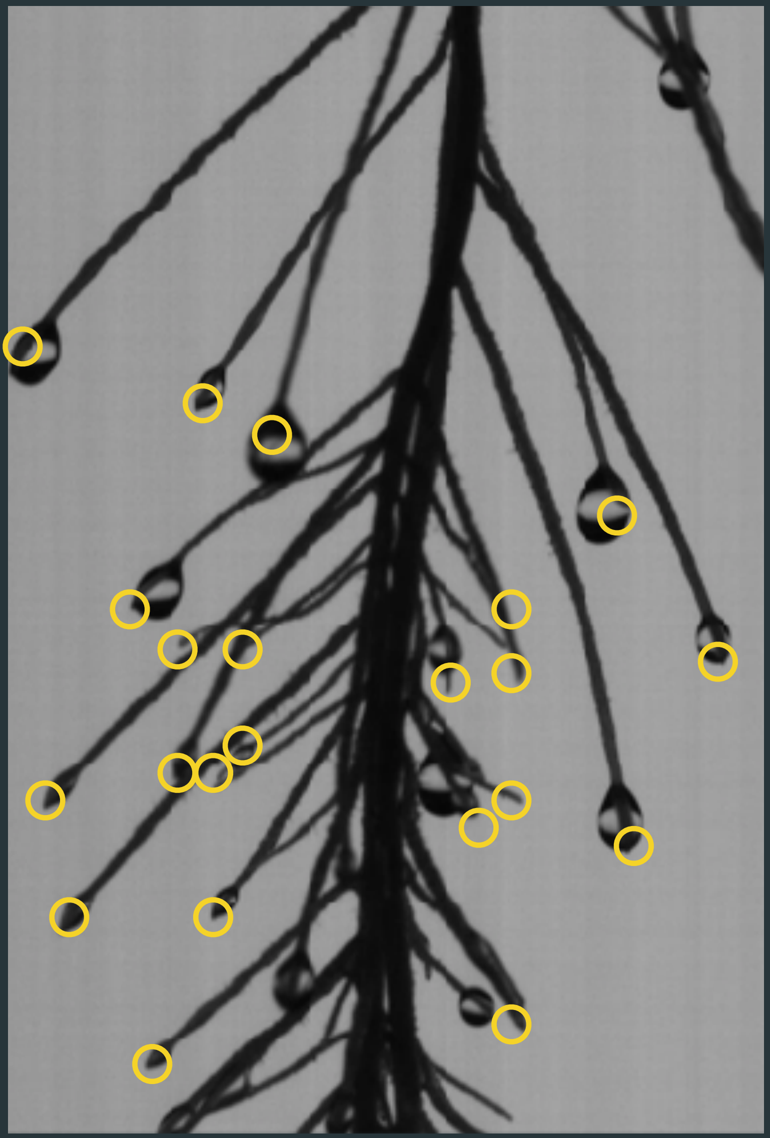
AUTOMATED TIP DETECTION

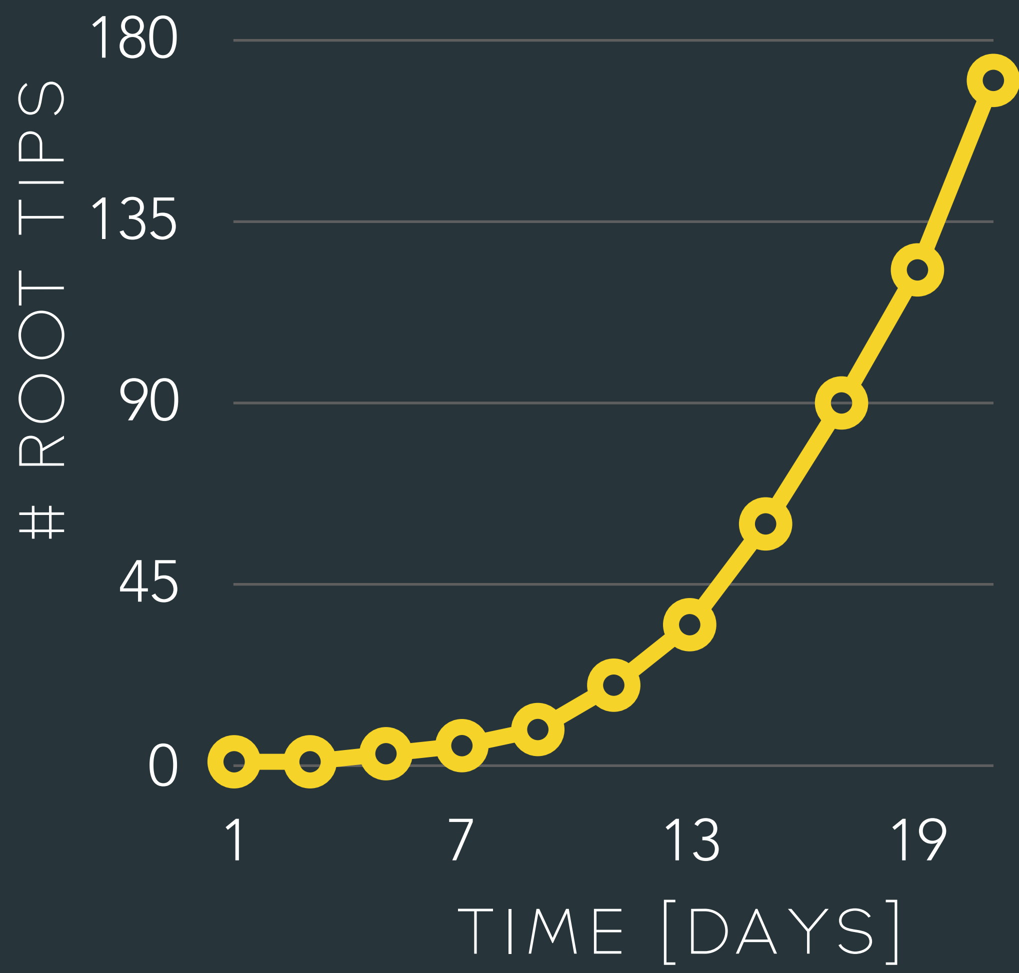


AUTOMATED TIP DETECTION

AUTOMATED TIP DETECTION

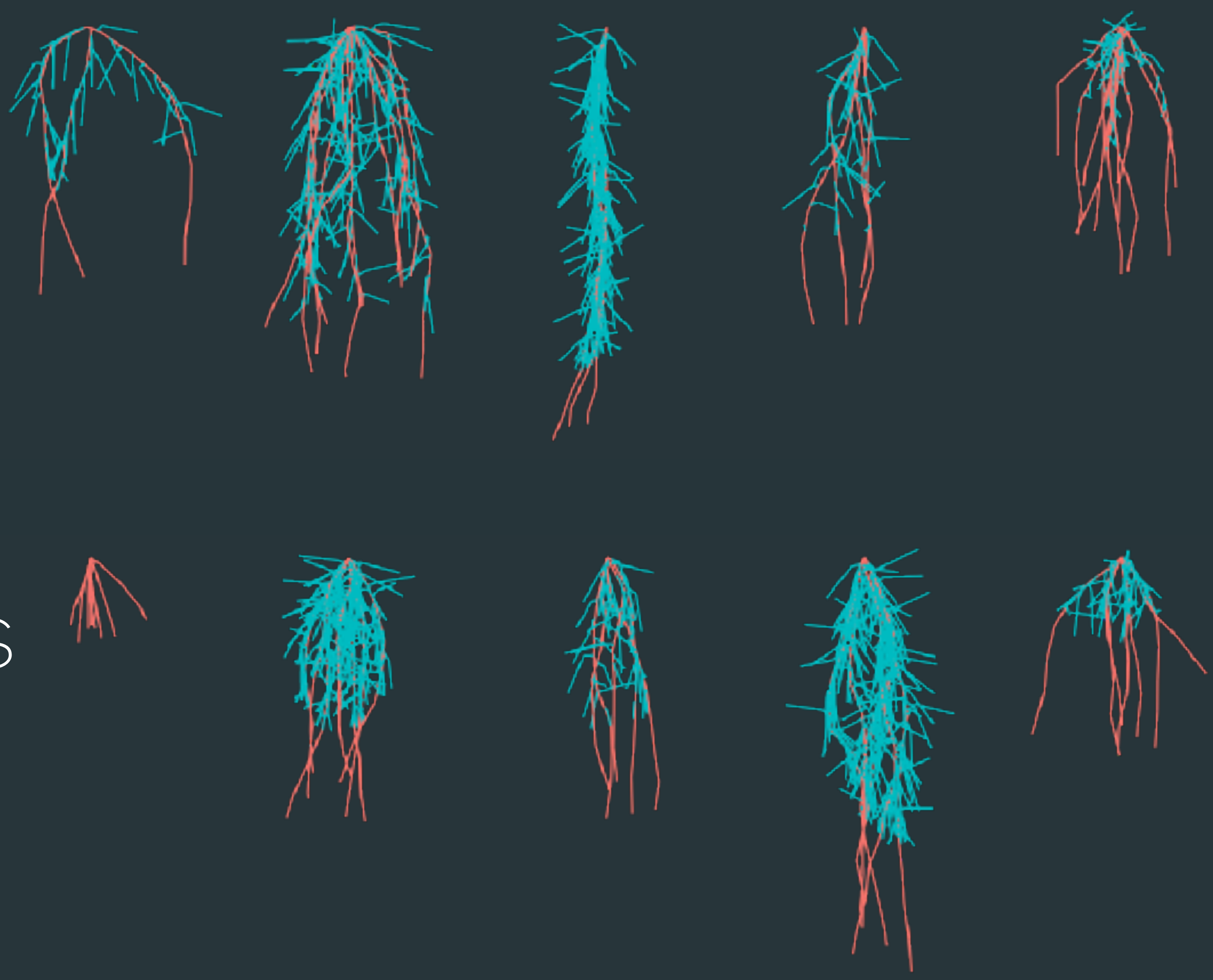






USING **CROOTBOX** TO CREATE A CUSTOM SYNTHETIC LIBRARY

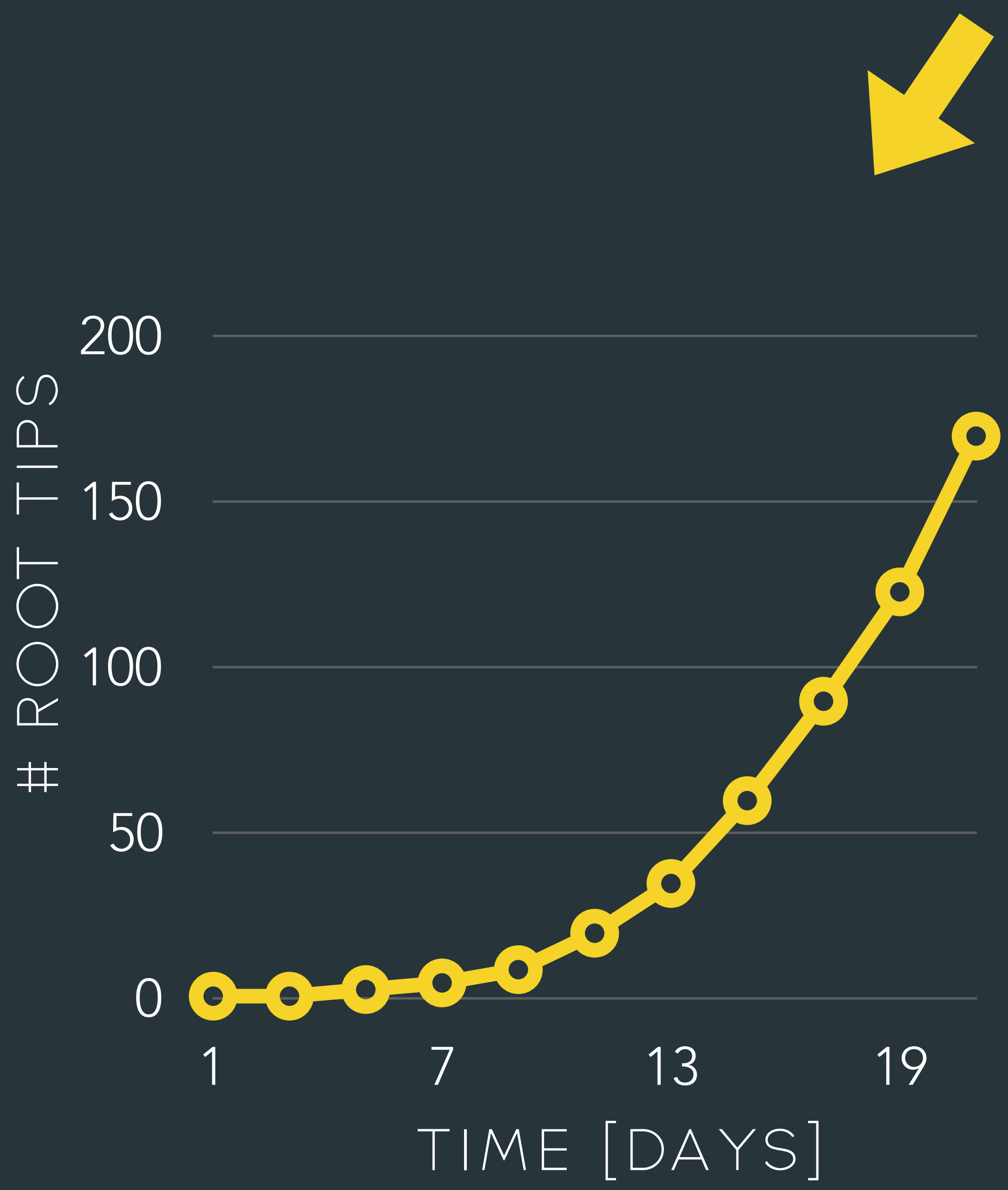
1. DEFINE BASE PARAMETER SET
2. RUN MODEL WITH DEVIATIONS
3. STORE PARAMETERS AND RSMLS

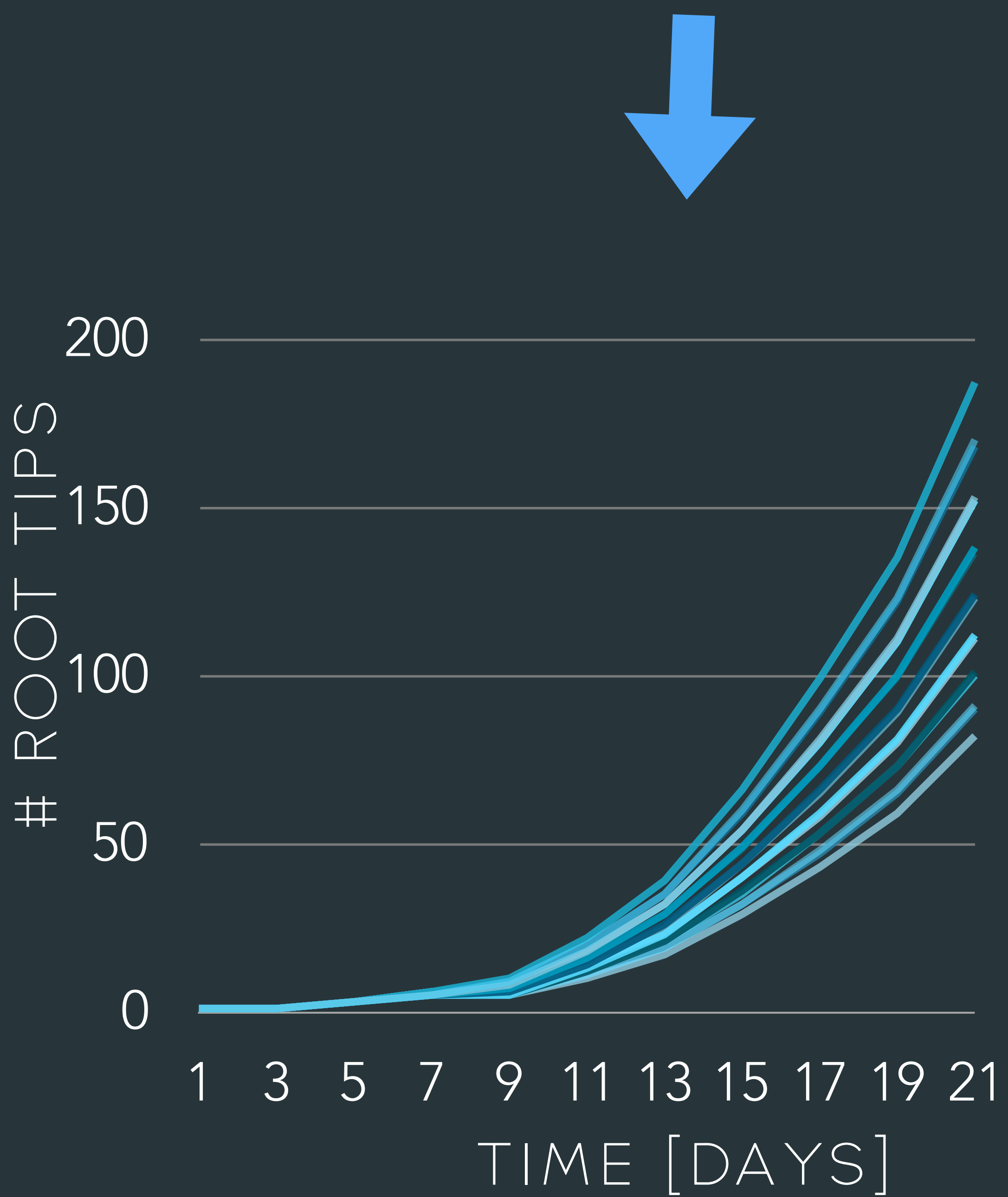


Schnepf et al. 2018
PMID: 29432520

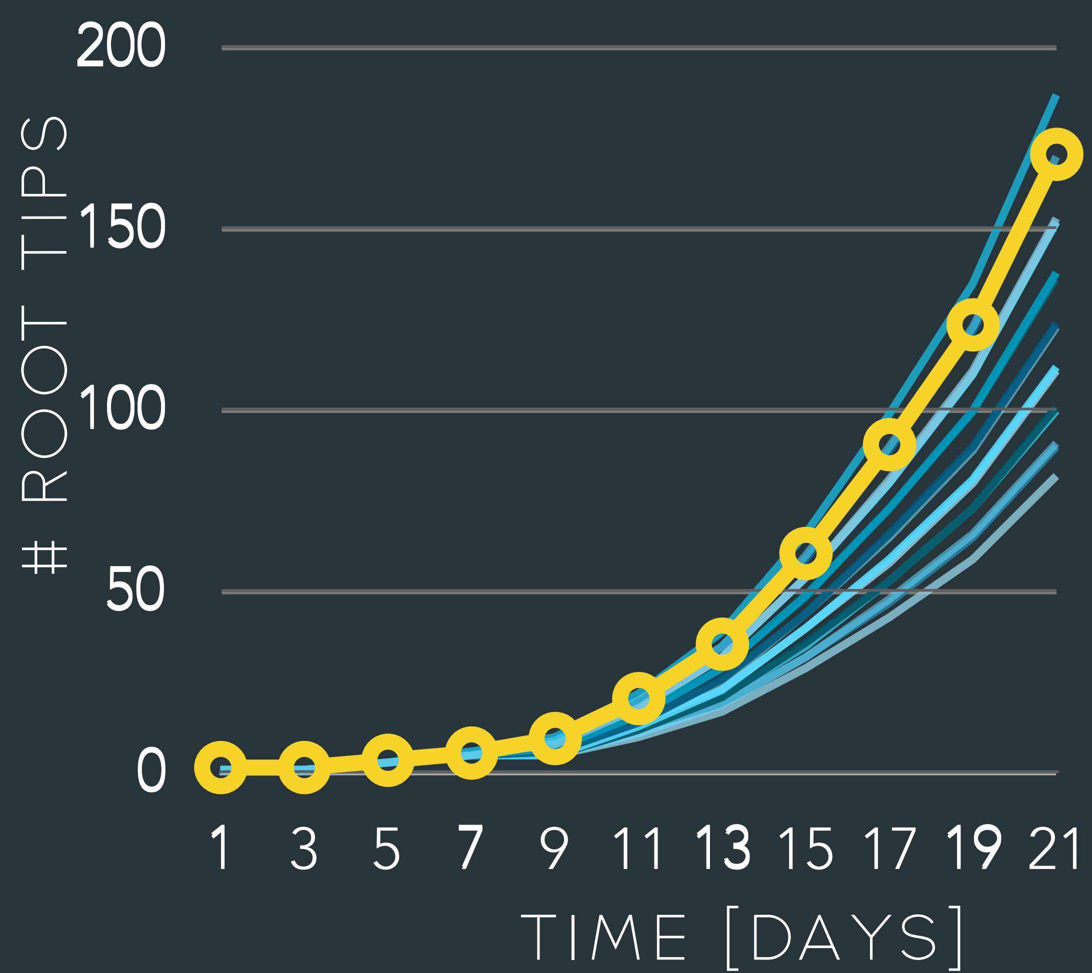
http://bit.ly/crootbox

FITTING EXPERIMENTS TO MODELS

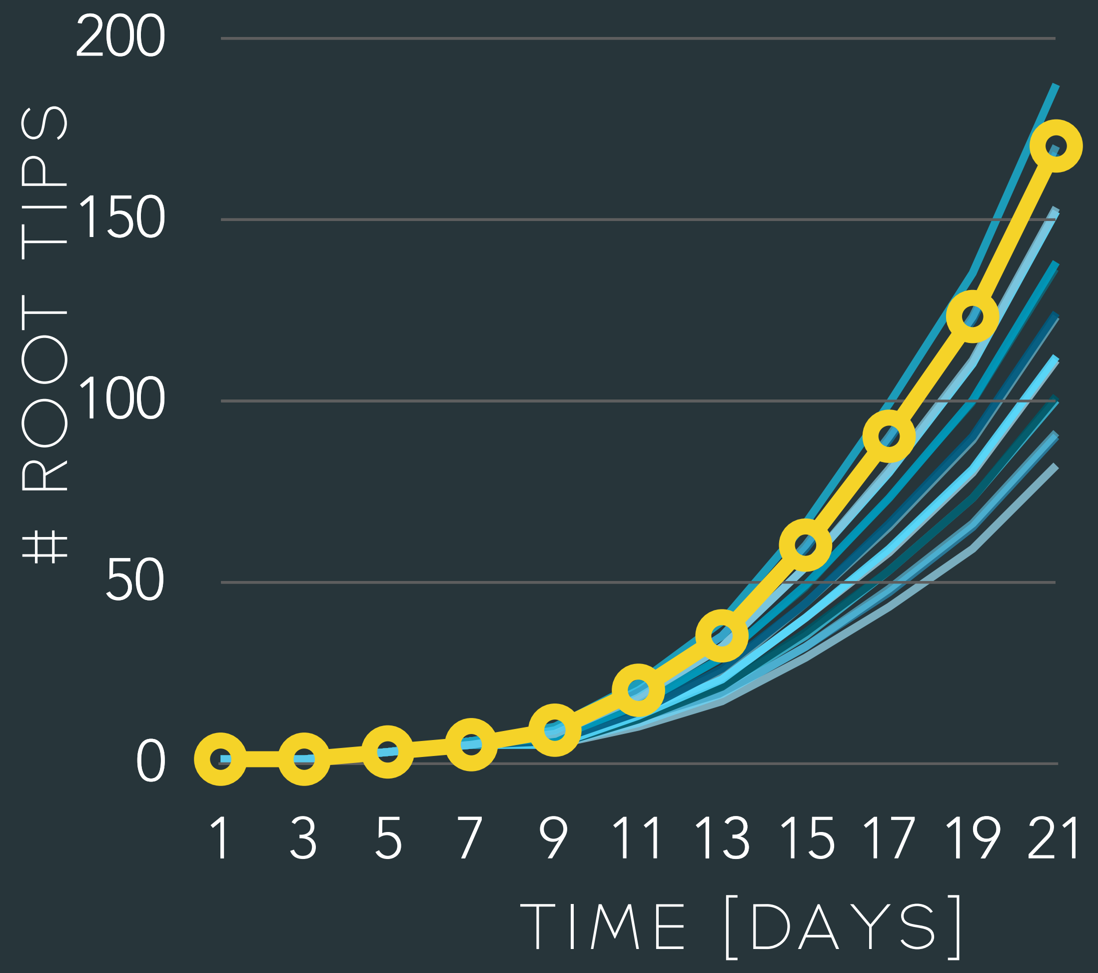




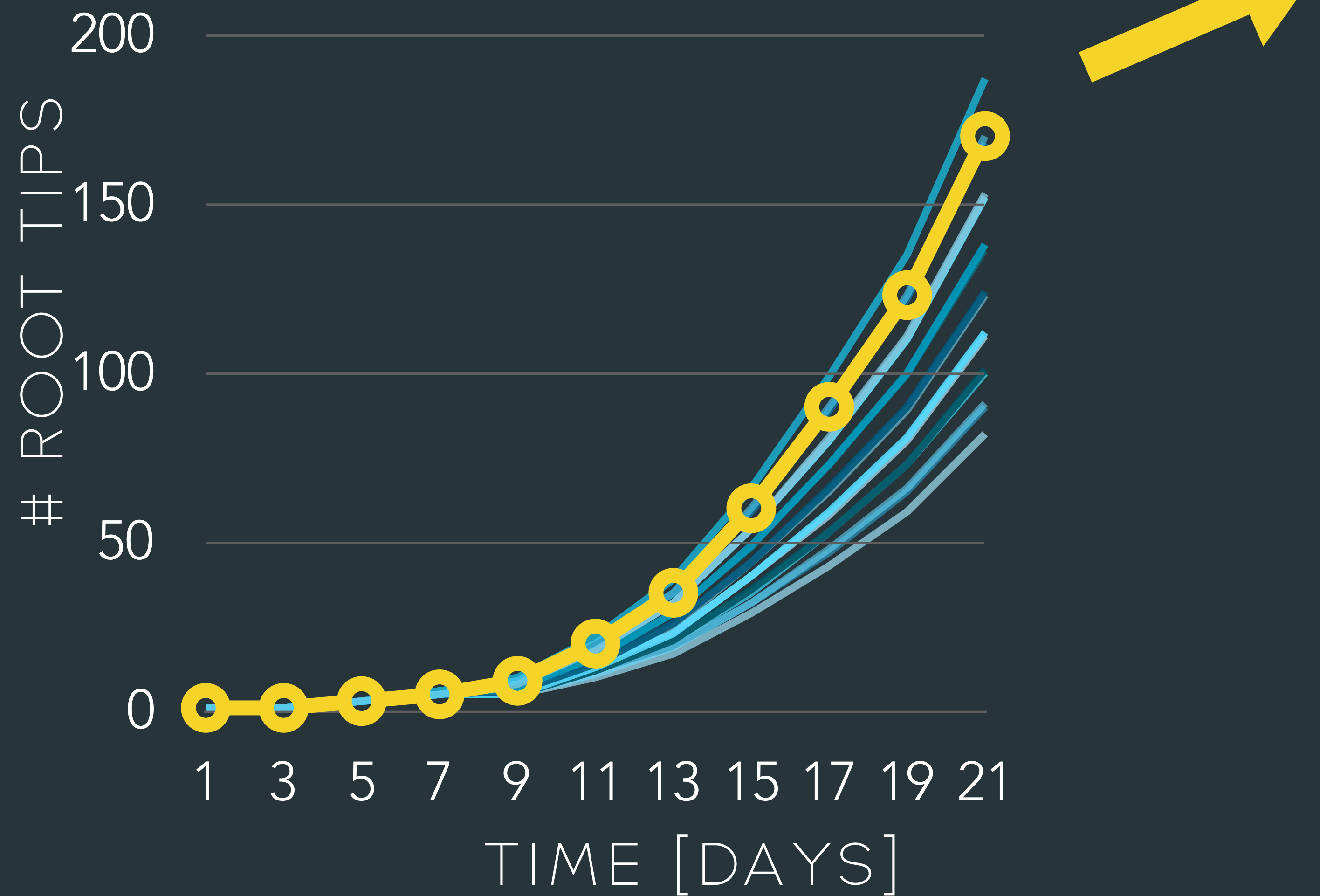
FITTING **EXPERIMENTS** TO **MODELS**



FITTING EXPERIMENTS TO MODELS

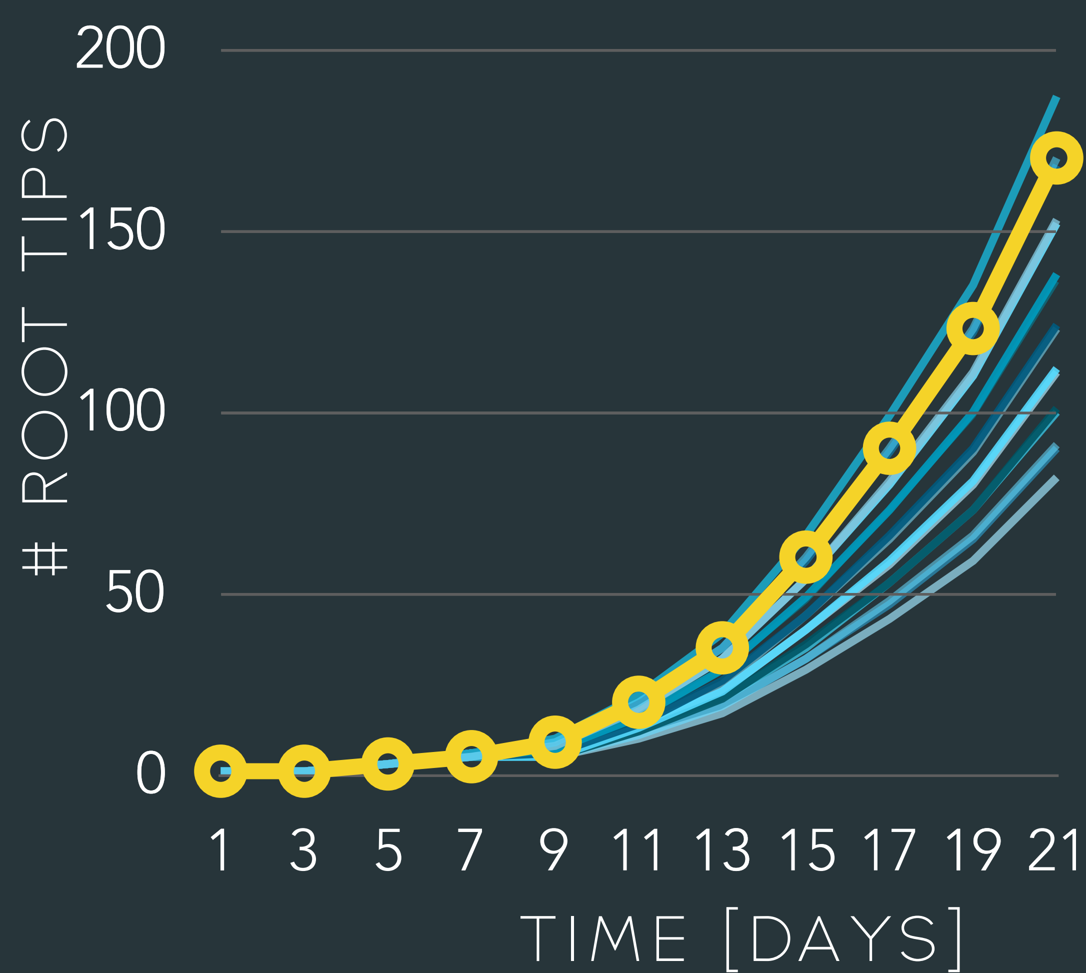


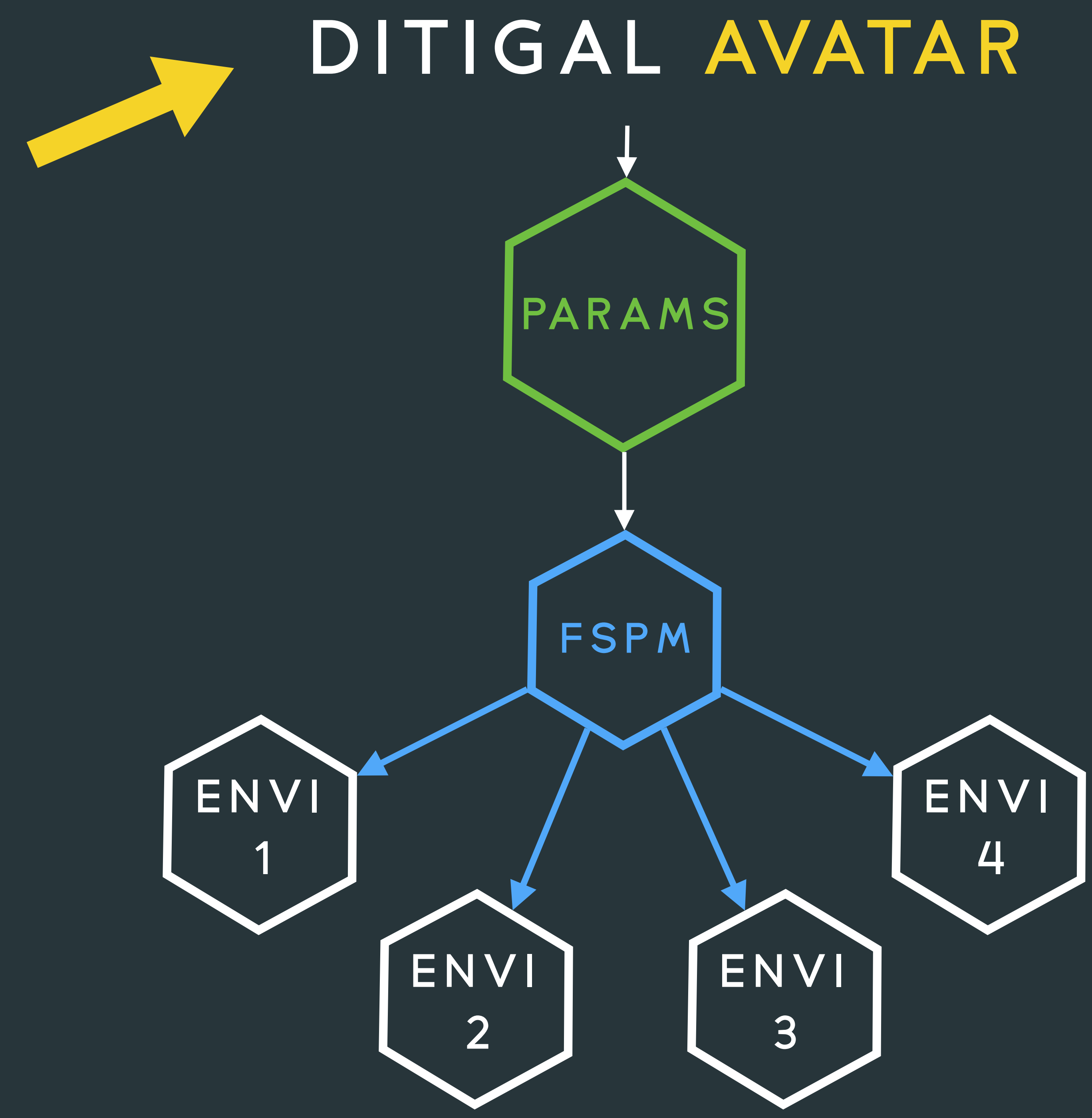
FITTING EXPERIMENTS TO MODELS

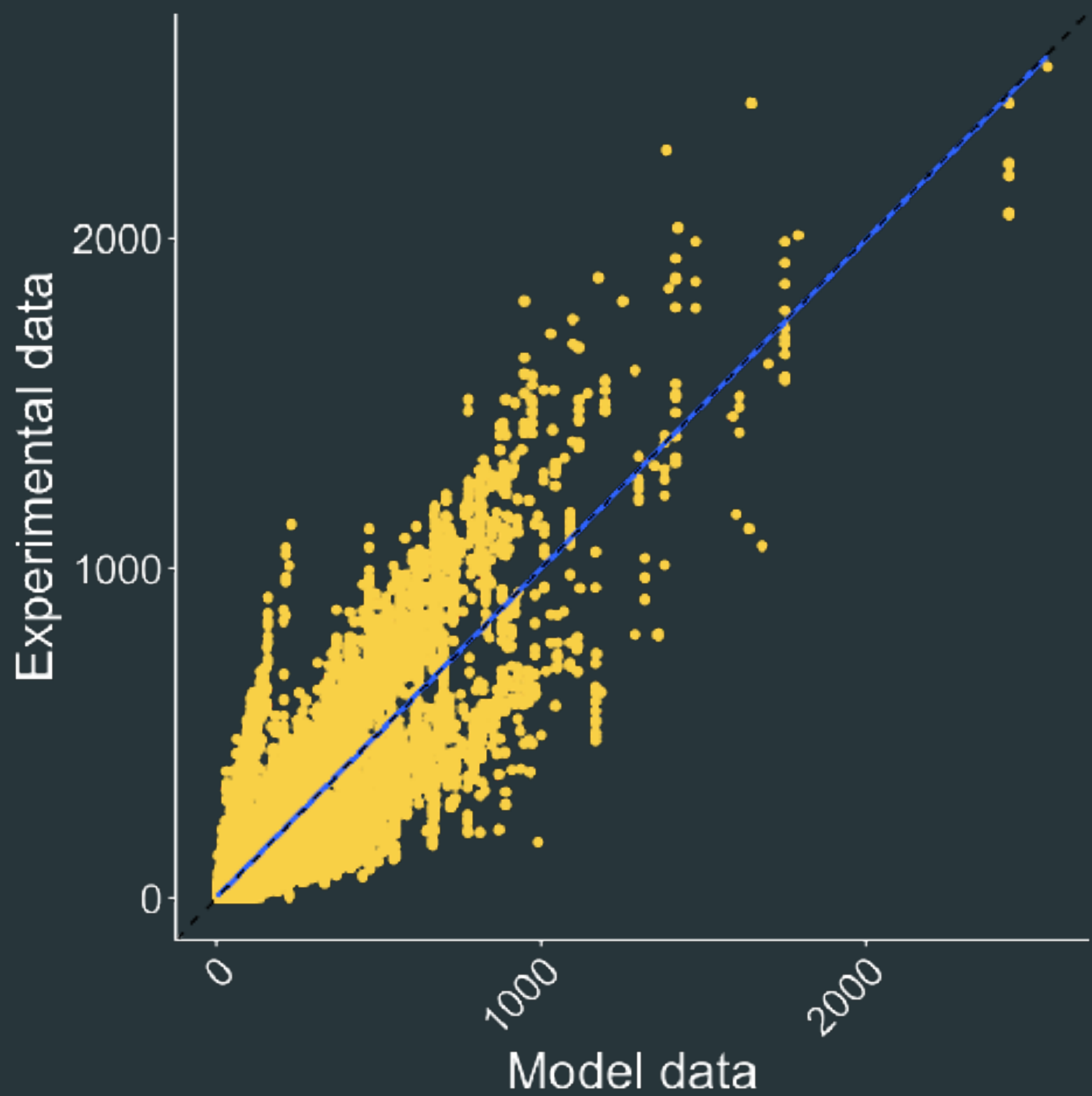


DITIGAL AVATAR

FITTING EXPERIMENTS TO MODELS







GOOD FIT
BETWEEN
EXPERIMENTAL
AND
MODELLED DATA

1000 PLANTS

MEAN R2 > 0.9

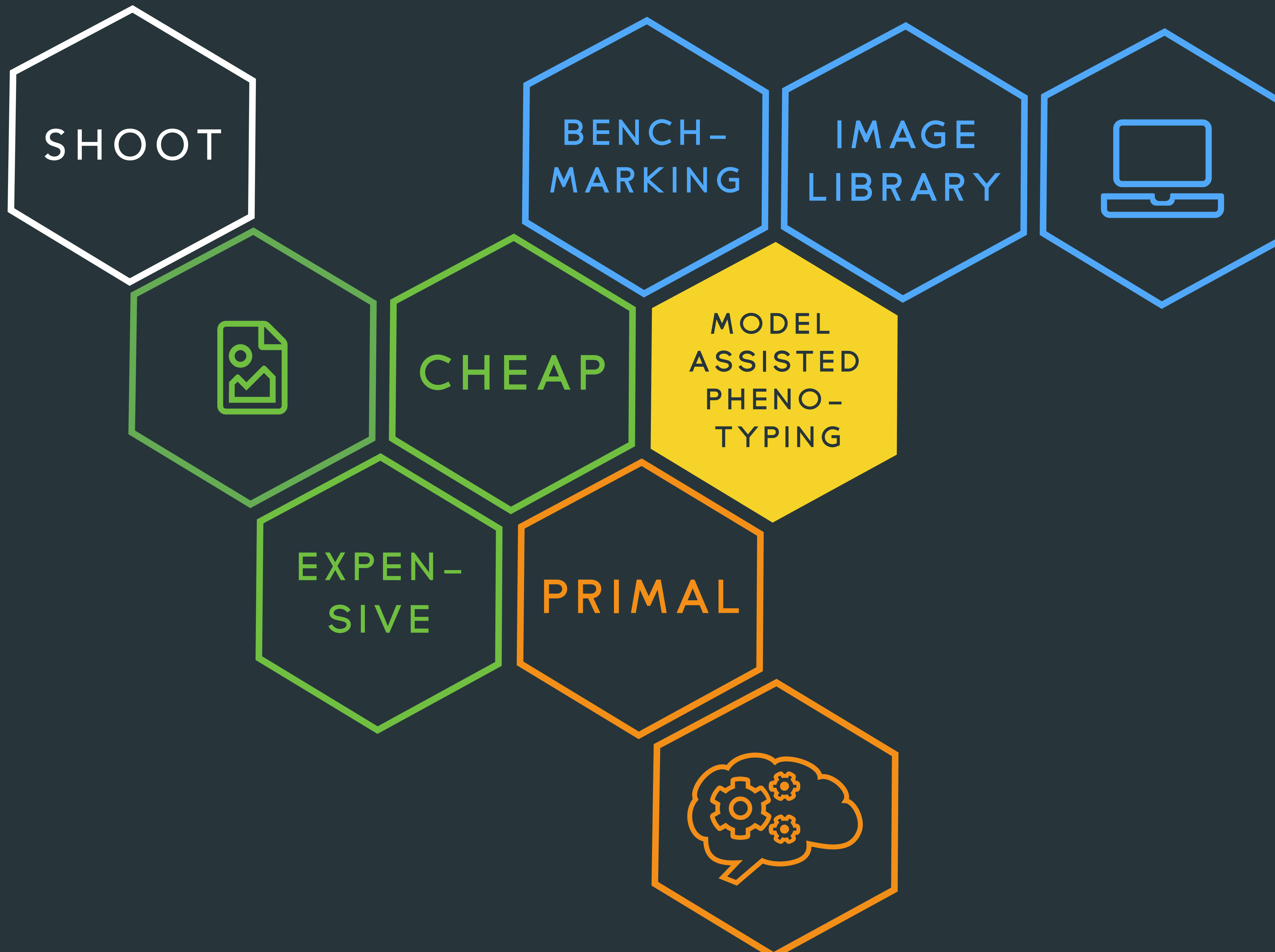

WORK
IN
PROGRESS


CHEAP
EXPEN-
SIVE

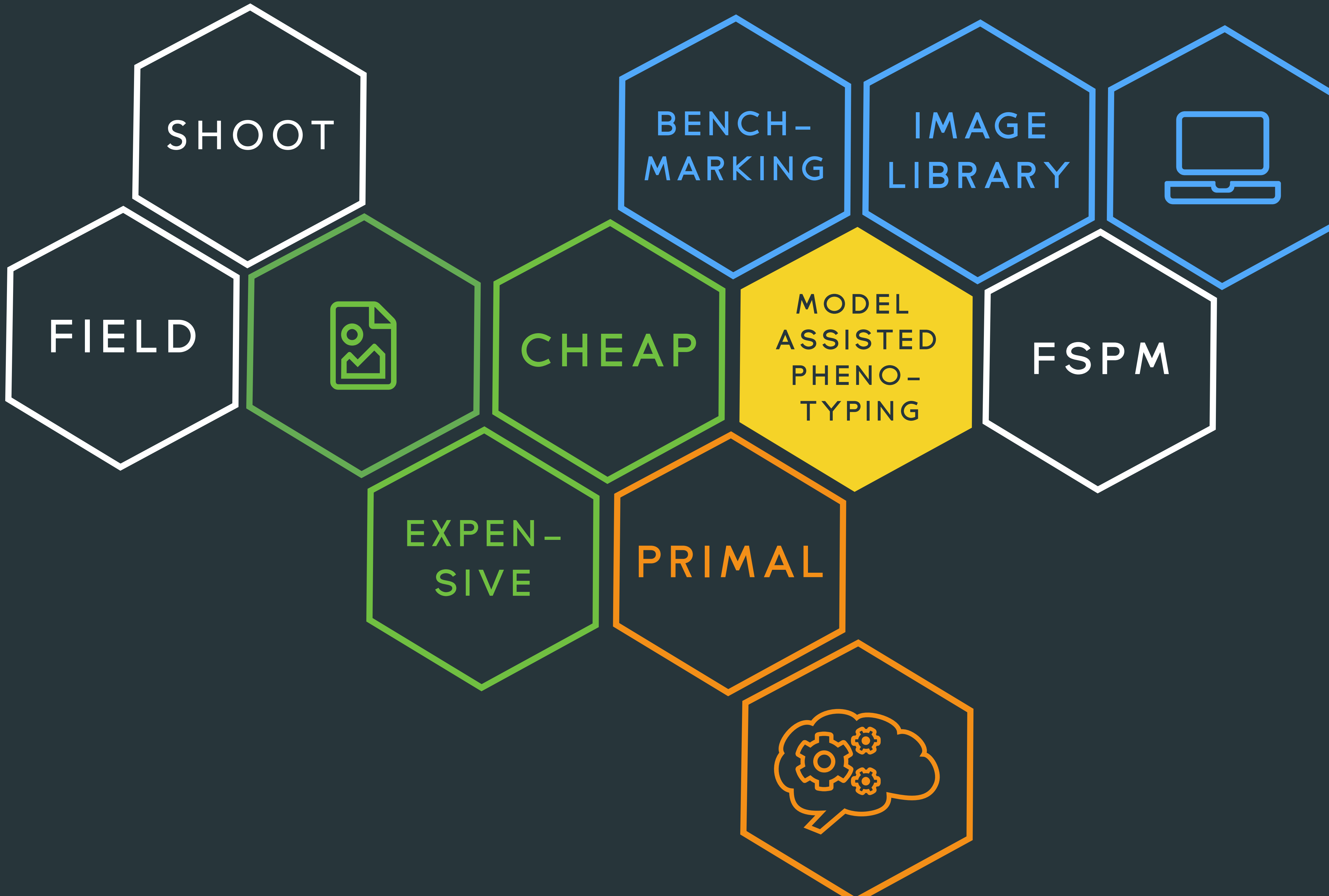

BENCH-
MARKING
IMAGE
LIBRARY
CHEAP
EXPEN-
SIVE


BENCH-
MARKING
IMAGE
LIBRARY
CHEAP
EXPEN-
SIVE
PRIMAL


BENCH-
MARKING
IMAGE
LIBRARY
CHEAP
MODEL
ASSISTED
PHENO-
TYPING
EXPEN-
SIVE
PRIMAL


SHOOT
BENCH-
MARKING
IMAGE
LIBRARY
CHEAP
MODEL
ASSISTED
PHENO-
TYPING
EXPEN-
SIVE
PRIMAL


SHOOT
FIELD
BENCH-
MARKING
IMAGE
LIBRARY
CHEAP
MODEL
ASSISTED
PHENO-
TYPING
EXPEN-
SIVE
PRIMAL


SHOOT
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BENCH-
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CHEAP
MODEL
ASSISTED
PHENO-
TYPING
FSPM
EXPEN-
SIVE
PRIMAL


SHOOT
FIELD
BENCH-
MARKING
IMAGE
LIBRARY
CHEAP
MODEL
ASSISTED
PHENO-
TYPING
FSPM
EXPEN-
SIVE
PRIMAL
DEEP
LEARNING

THE FUTURE IS
TO COMBINE
IMAGE ANALYSIS,
MODELLING AND
MACHINE LEARNING

THANK YOU
ANY QUESTIONS ?

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fnrs
LA LIBERTÉ DE CHERCHER

JÜLICH
Forschungszentrum

Presentation available on figshare

bit.ly/lobet-phenome