From Online Behaviours to Images: A Novel Approach to Social Bot Detection

Edoardo Di Paolo[1], Marinella Petrocchi[2] and Angelo Spognardi[1]

[1] Computer Science dept., Sapienza University of Rome, Italy

[2] IIT-CNR, Pisa, Italy

**Prague 5 July, ICCS 2023**

Introduction

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Growth in the use of Online Social Networks

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Proliferation of **fake news** and **disinformation** online

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

In this work we focused on
Twitter

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi
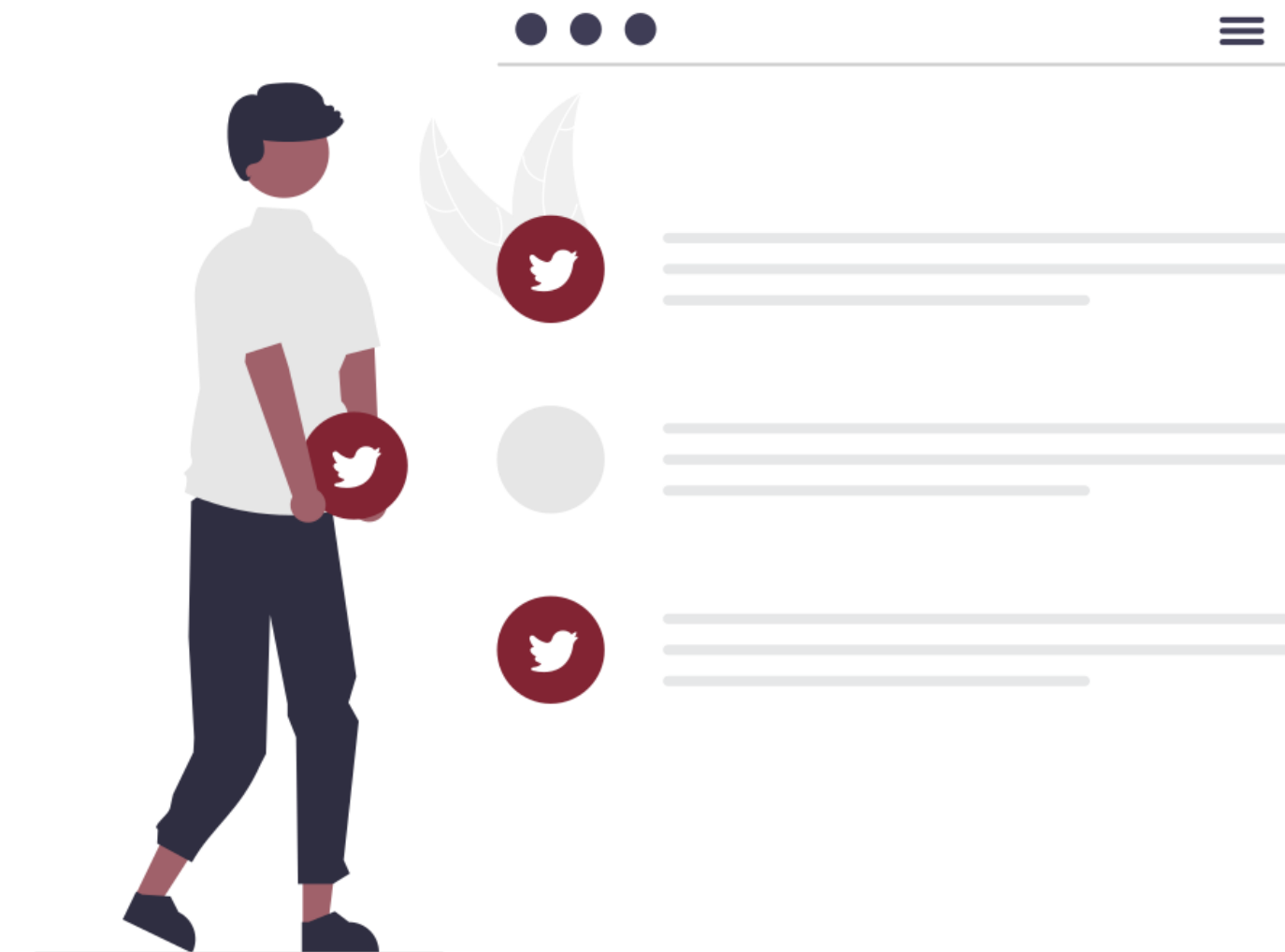
A **bot** is an **automated account** that is able to replicate actions of a real user

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi
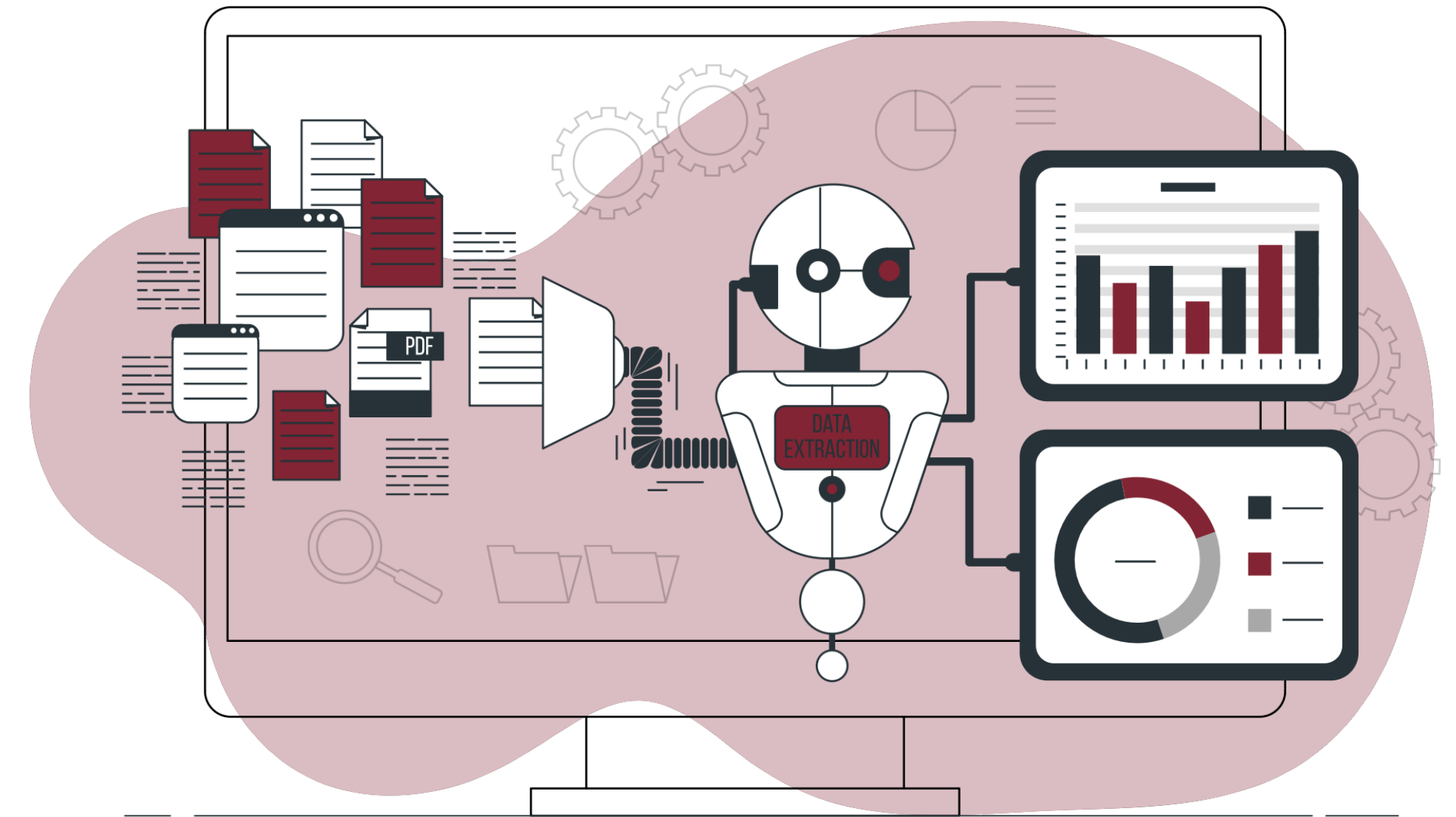
We **do not know** how many bots there are on Twitter; estimations are between **8%** and **18%**

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Different approaches proposed in literature

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Different approaches proposed in literature

1. **ML approaches** with a features set

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Different approaches proposed in literature

1. **ML approaches** with a features set

2. **NLP approaches** based on text analysis

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Different approaches proposed in literature

1. **ML approaches** with a features set

2. **NLP approaches** based on text analysis

3. **GNNs** that exploit users' relationships

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Digital DNA: a sequence that represents the actions of a given account

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

We define an **alphabet** to create the sequences:

We define an **alphabet** to create the sequences:

- "**A**" for a plain tweet

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

We define an **alphabet** to create the sequences:

- "**A**" for a plain tweet

- "**C**" for a retweet

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

We define an **alphabet** to create the sequences:

- "**A**" for a plain tweet

- "**C**" for a retweet

- "**T**" for a reply

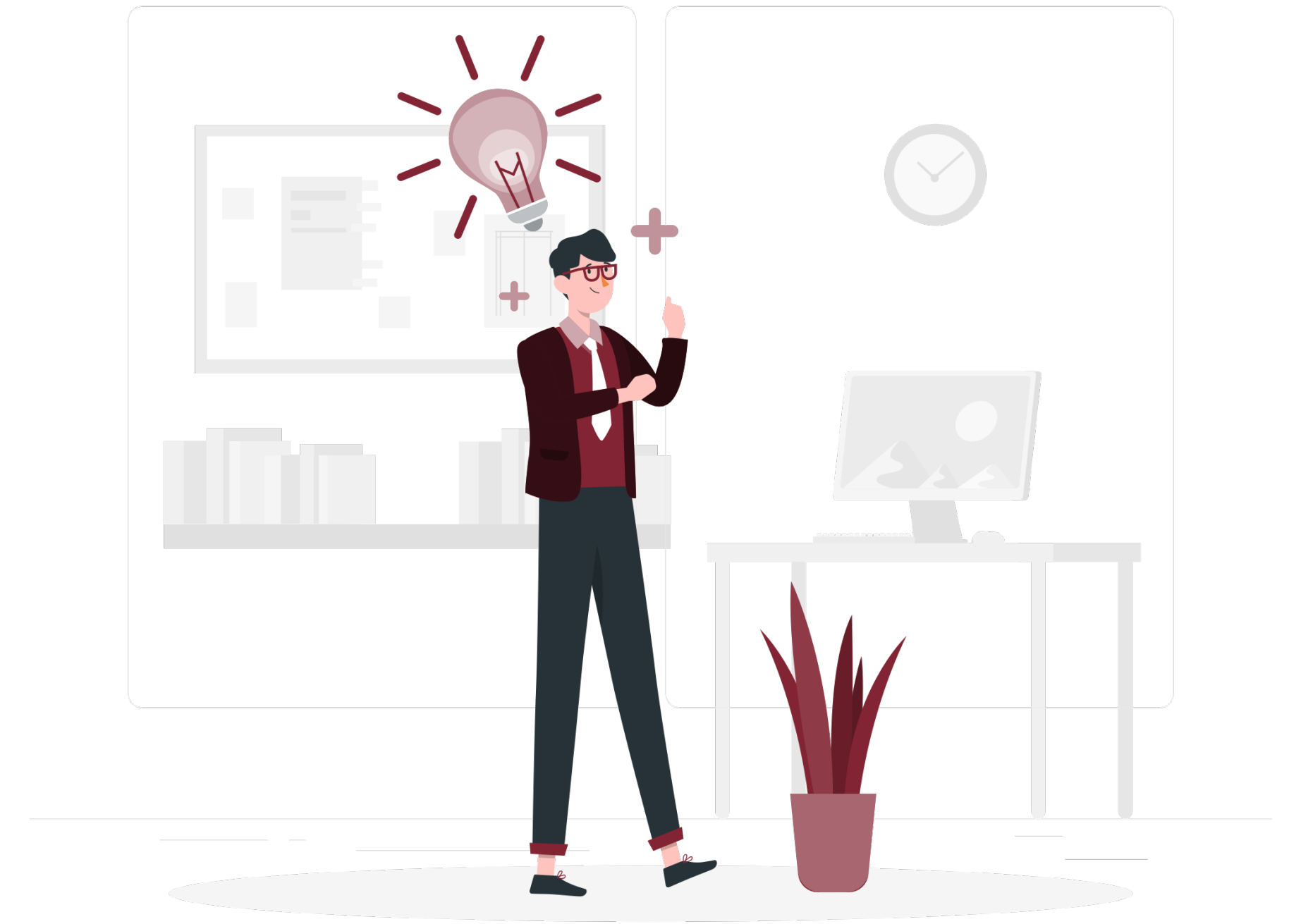Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

John has **two tweets** and **one reply**.

In this example, the sequence will be:
AAT

John
@john

My first tweet!

1:45 PM · Jul 5, 2023

John
@john

ICCS 2023!

1:50 PM · Jul 5, 2023

Pluto @pluto · Jul 5, 2023

Hi!

♡ 1

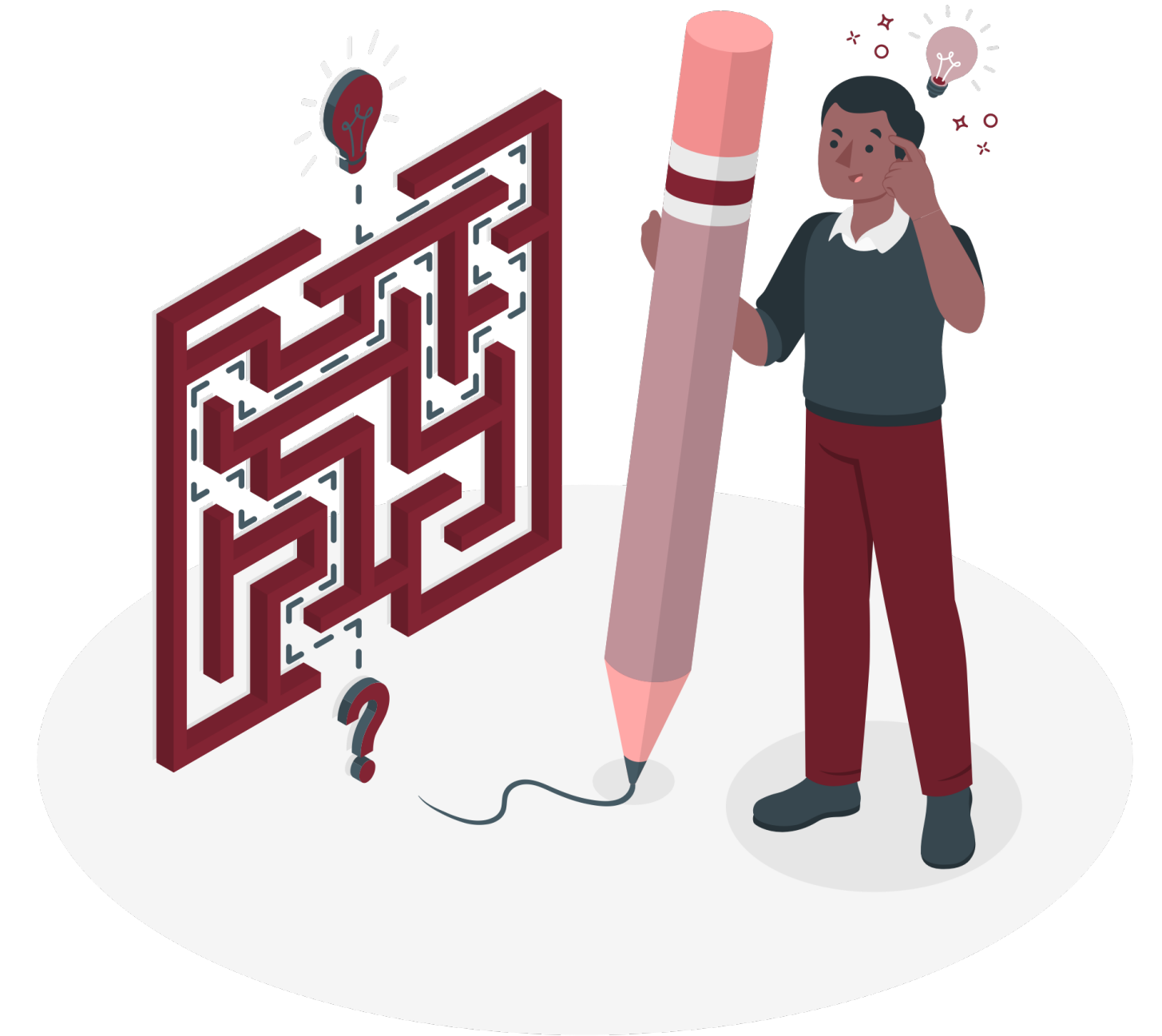**John** @john · Jul 5, 2023

Hi Pluto!

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

The new approach

Our idea: exploit the DNA sequences converting them into **images** and use **CNNs** for classification

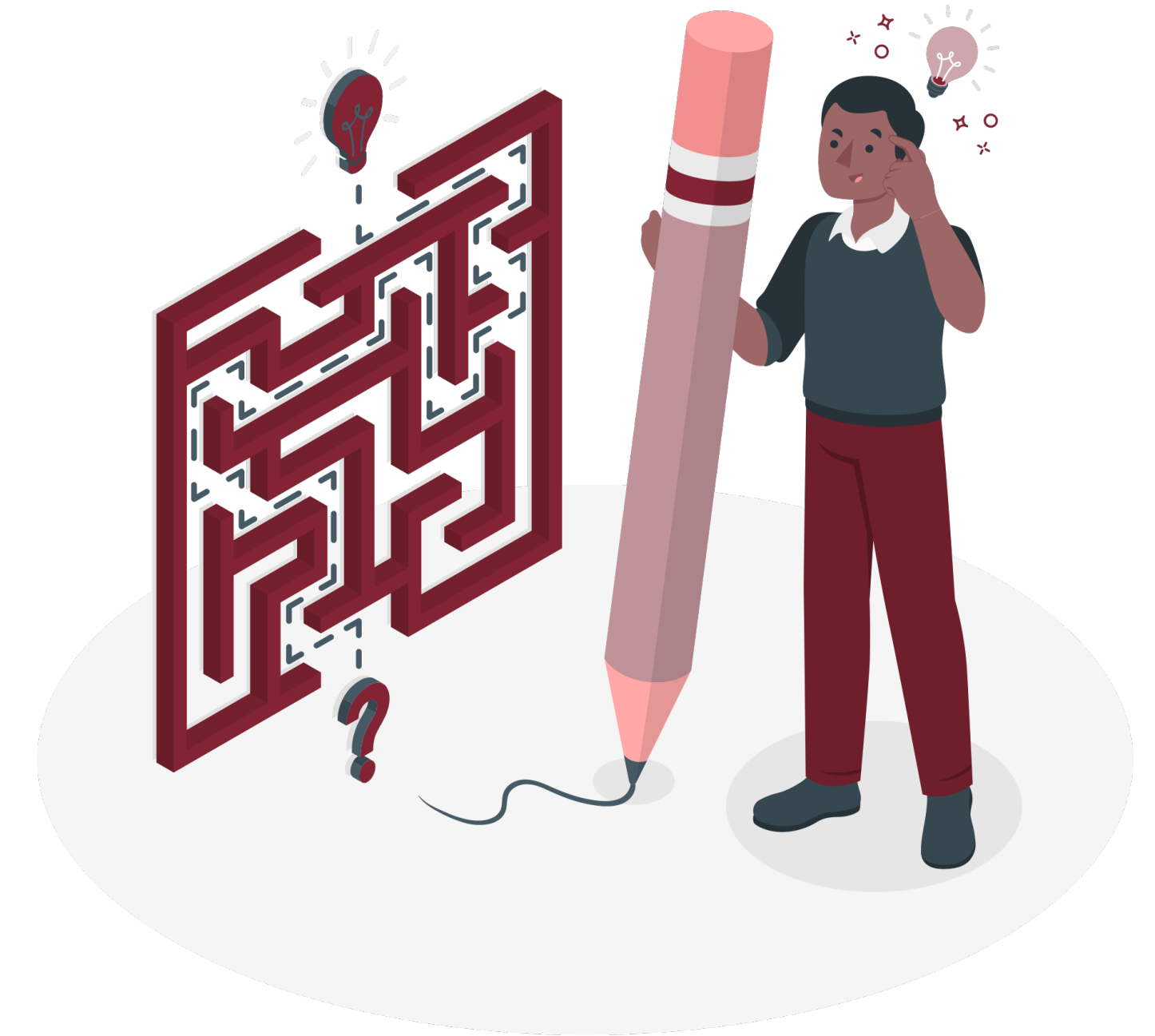Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Different challenges to solve:

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Different challenges to solve:

1. No useful methods to convert the sequences into images
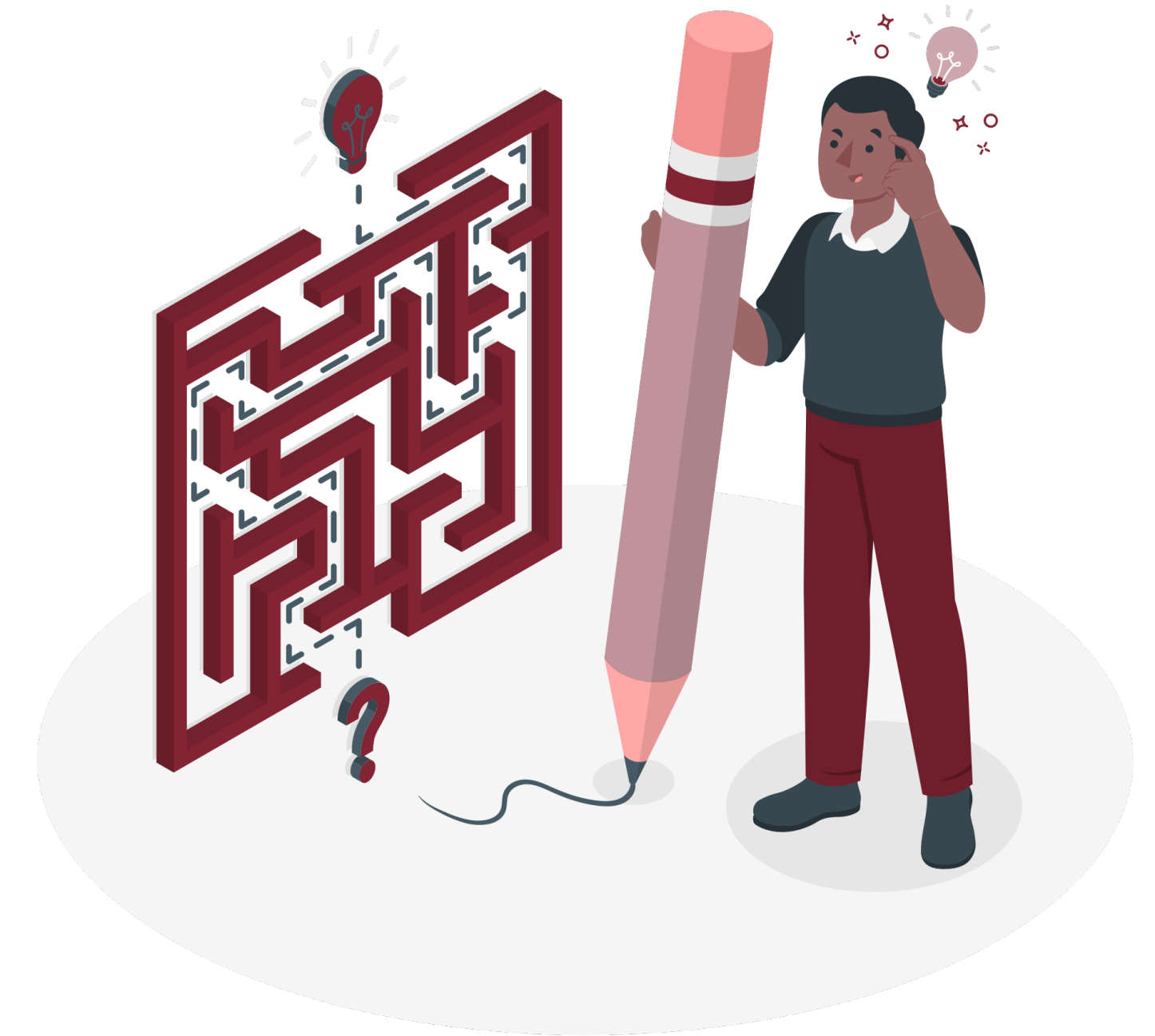
Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Different challenges to solve:

1. No useful methods to convert the sequences into images

2. Need to represent long strings (> 1000 chars)

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi
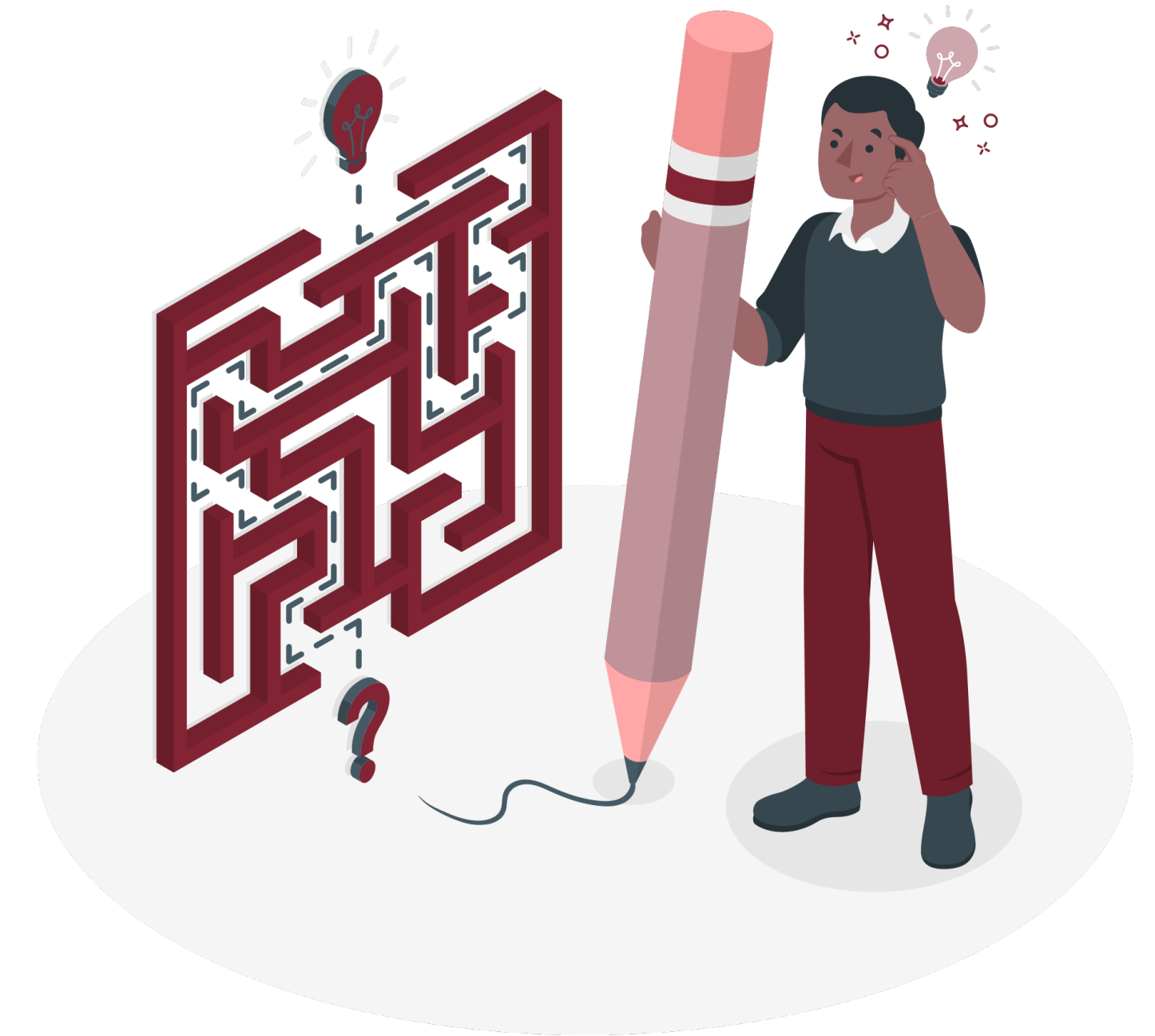
Different challenges to solve:

1. No useful methods to convert the sequences into images

2. Need to represent long strings (> 1000 chars)

3. Need to have image with recognizable patterns

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

We implemented an algorithm to solve the previous challenges

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

We implemented an algorithm to solve the previous challenges

1. **Convert** the DNA sequence into **2 dimensions**

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

We implemented an algorithm to solve the previous challenges

1. **Convert** the DNA sequence into **2 dimensions**

2. **Assign** to each symbol in the alphabet **a color**

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

We implemented an algorithm to solve the previous challenges

1. **Convert** the DNA sequence into **2 dimensions**

2. **Assign** to each symbol in the alphabet **a color**

3. Generate the image

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

An example of our approach

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

An example of our approach

DNA sequence
ACTTACTAAAACT

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

An example of our approach

DNA sequence
ACTTACTAAAACT

An example of our approach

DNA sequence

ACTTACTAAAACT

A	C	T	T
A	C	T	A
A	A	A	C
T	/	/	/

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Real Twitter accounts

Bot Twitter accounts

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi
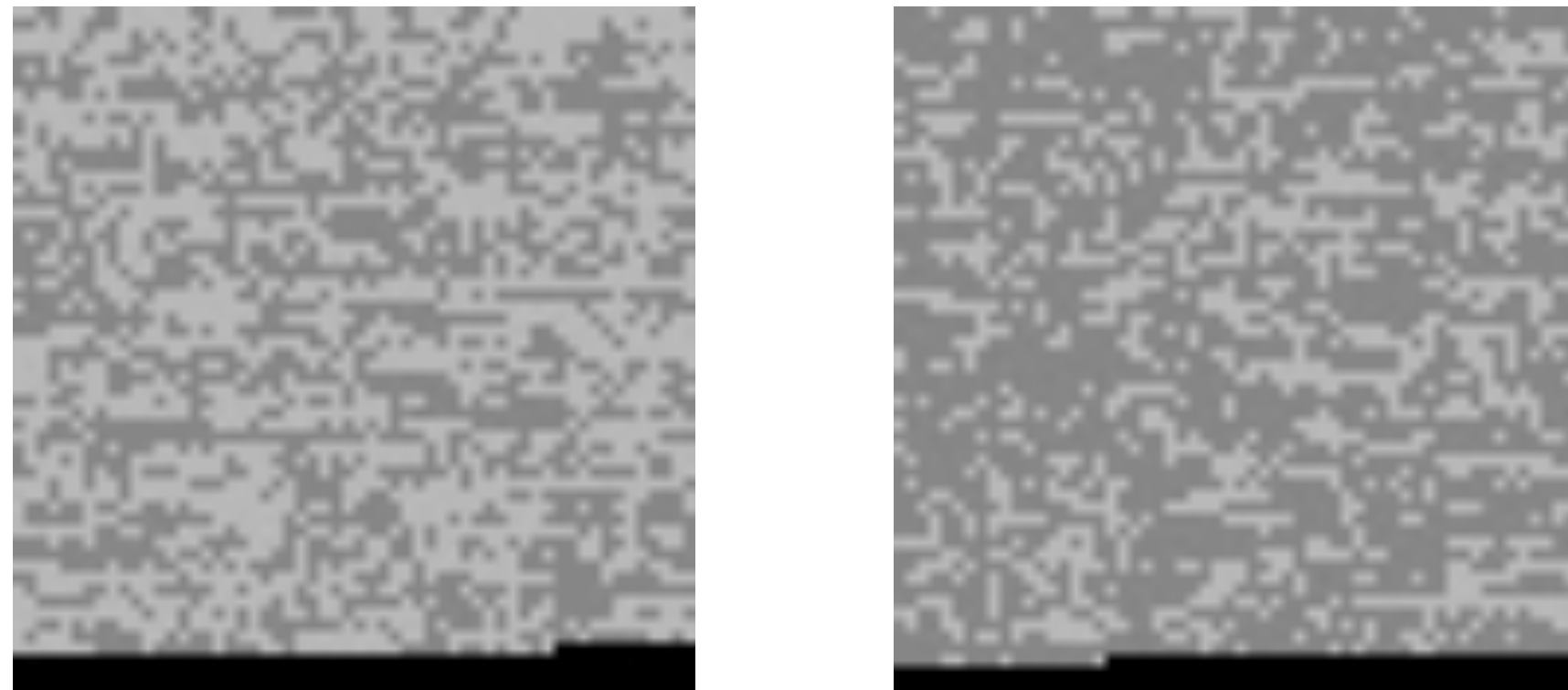
Experiments and results

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Results on **Cresci-2017** dataset with **991 bots** and **1083 users**

	MCC	Accuracy	Recall	F1 score
Feng et al.	0.96	0.98	-	0.98
Our approach	0.98	0.98	0.98	0.98

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Results on **Cresci-stock-2018** dataset with **6842 bots** and **5882 users**

	MCC	Accuracy	Recall	F1 score
Antenore et al.	-	0.77	0.96	0.82
Our approach	0.78	0.89	0.88	0.89

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

In **TwiBot20** there are **6561 bots** and
5185 users

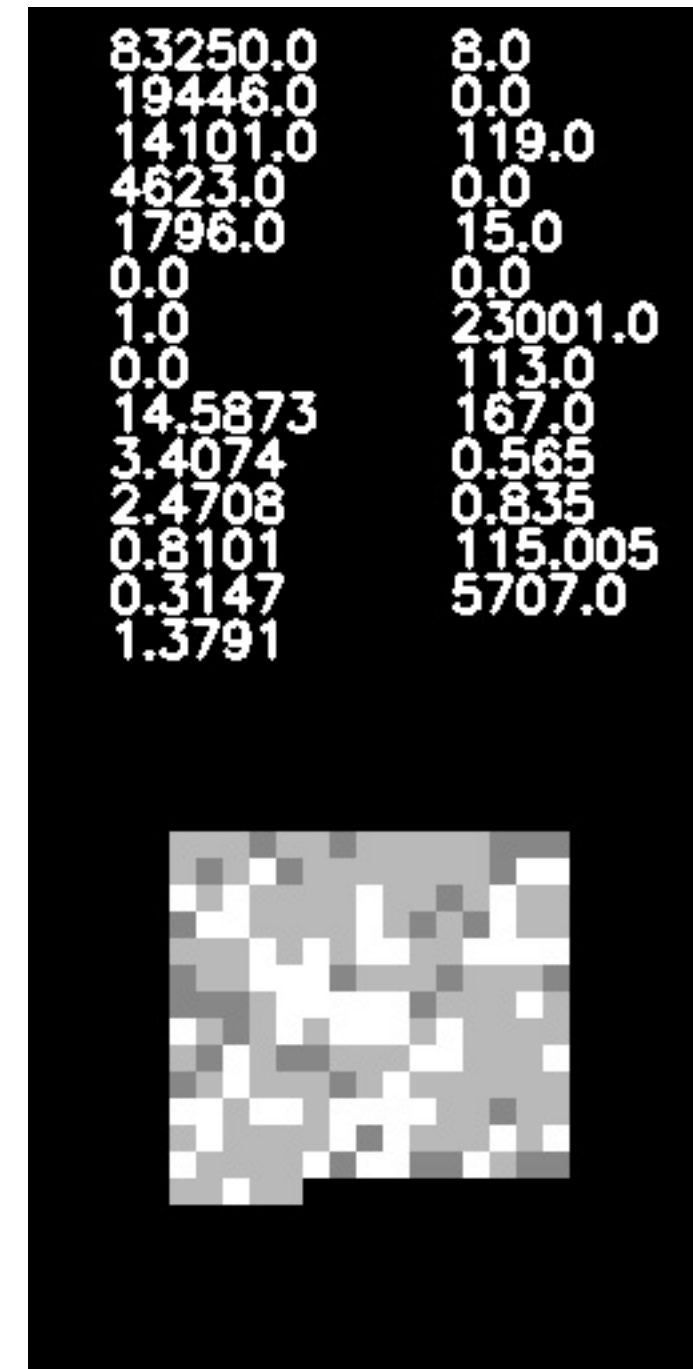Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

In **TwiBot20** there are **6561 bots** and **5185 users**

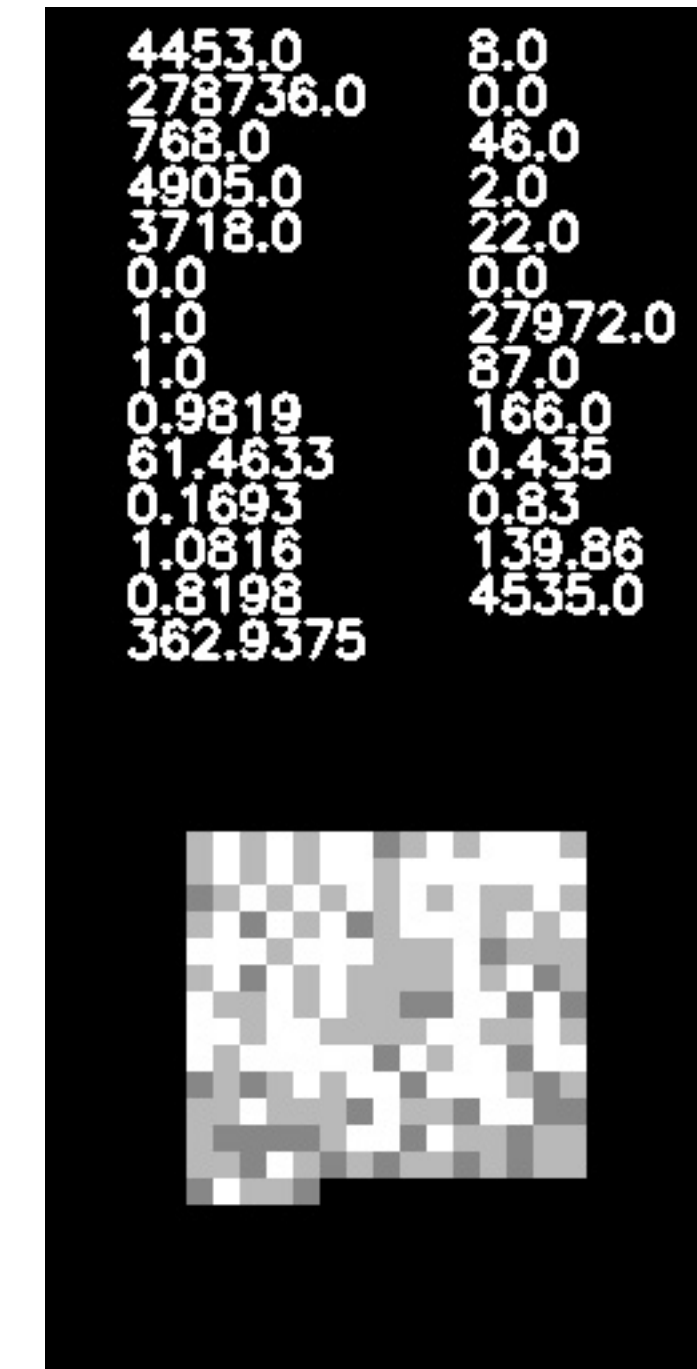**Problem**: in the dataset there is a maximum of 200 tweets per user and then images are at most 15x15 in size

In **TwiBot20** there are **6561 bots** and
5185 users

Problem: in the dataset there is a
maximum of 200 tweets per user and
then images are at most 15x15 in size

Too small for a classification!

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Solution: use a features set in the images exploiting another approach called **SuperTML**

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi
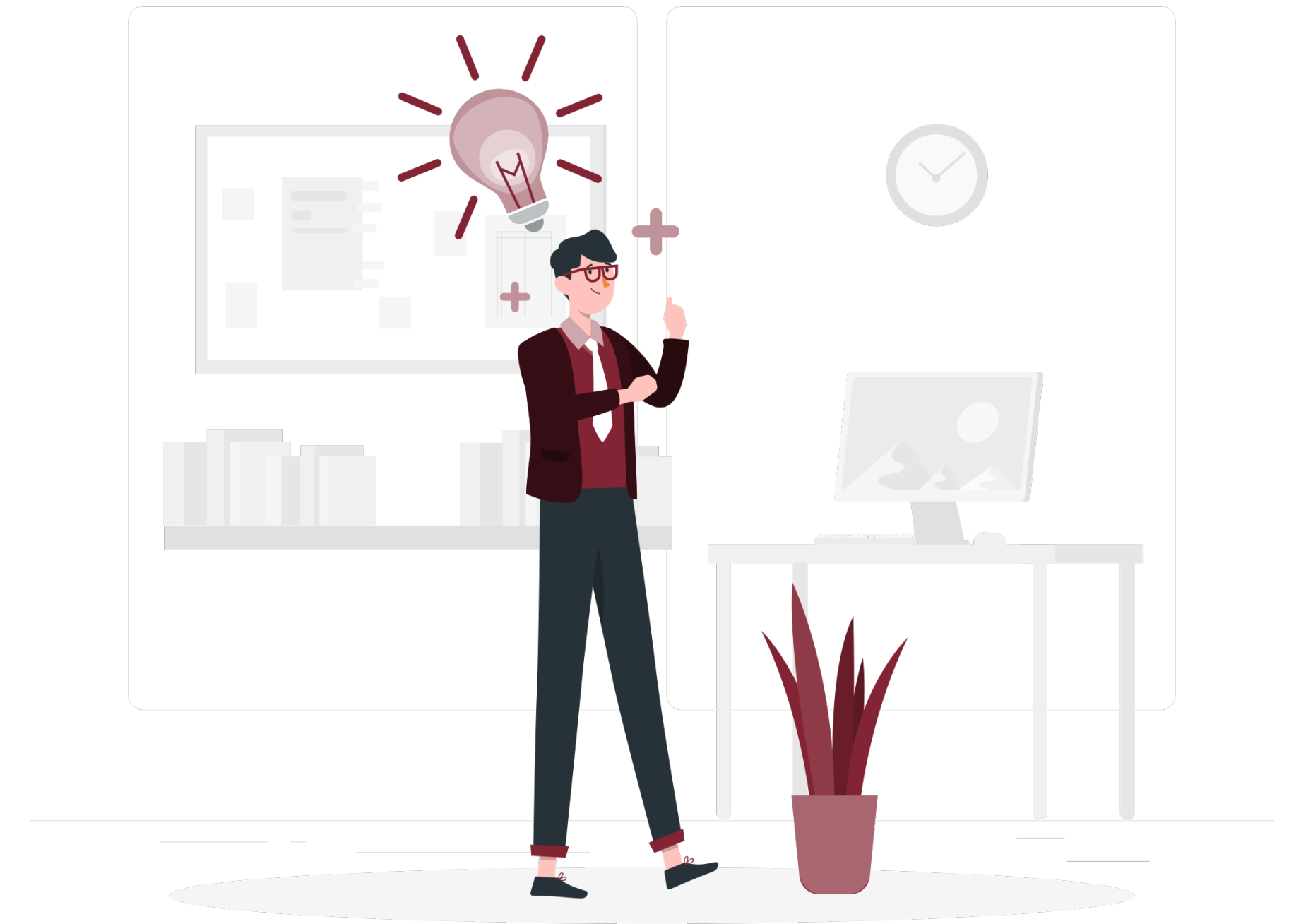
Bot Twitter account in TwiBot20

Real Twitter account in TwiBot20

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Results on **TwiBot20** dataset

	MCC	Accuracy	Recall	F1 score
Feng et al.	0.67	0.81	-	0.85
Our approach	0.67	0.81	0.80	0.80

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

Conclusions and Future works

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

From Online Behaviours to Images: A Novel Approach to Social Bot Detection

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

- Proposed a new approach to bot detection

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi

- Proposed a new approach to bot detection

- Achieved excellent results on publicly available datasets

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi
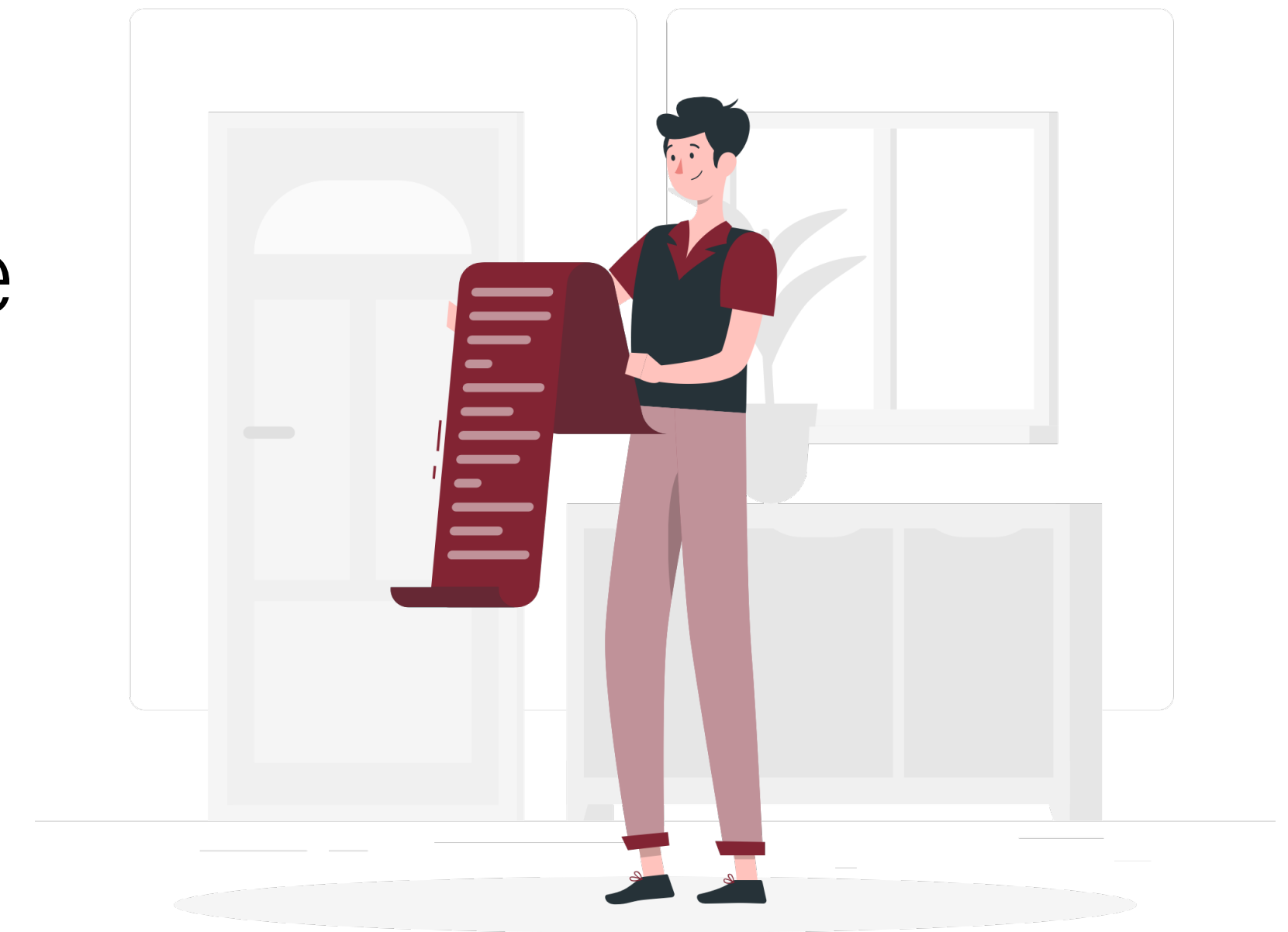
- Proposed a new approach to bot detection

- Achieved excellent results on publicly available datasets

- Exploit account's features and relationships

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi
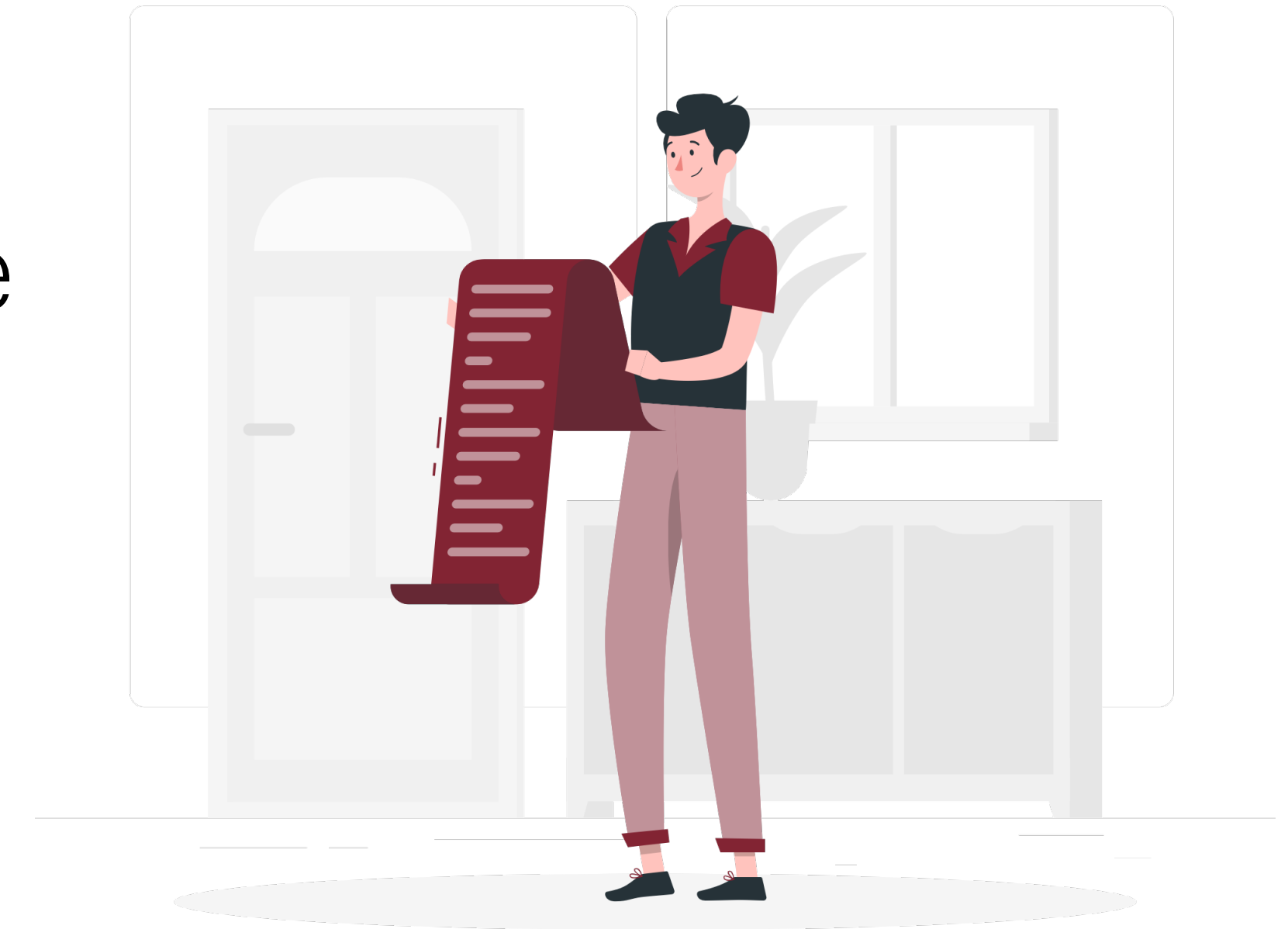
- Proposed a new approach to bot detection

- Achieved excellent results on publicly available datasets

- Exploit account's features and relationships

- Try to develop ensemble methods

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi
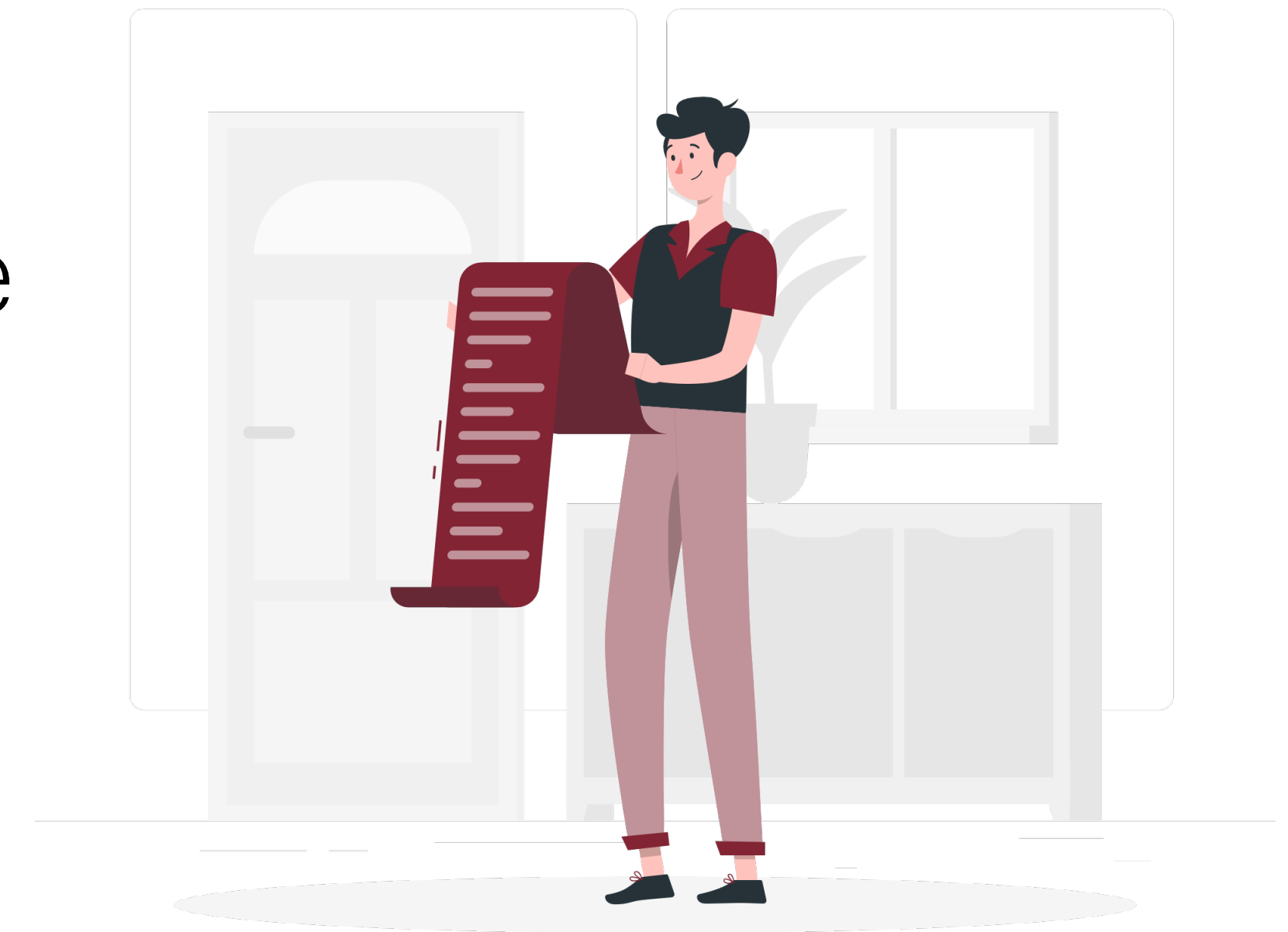
Thank you!

dipaolo@di.uniroma1.it

Edoardo Di Paolo, Marinella Petrocchi, Angelo Spognardi