

# **LINEAR ALGEBRA**

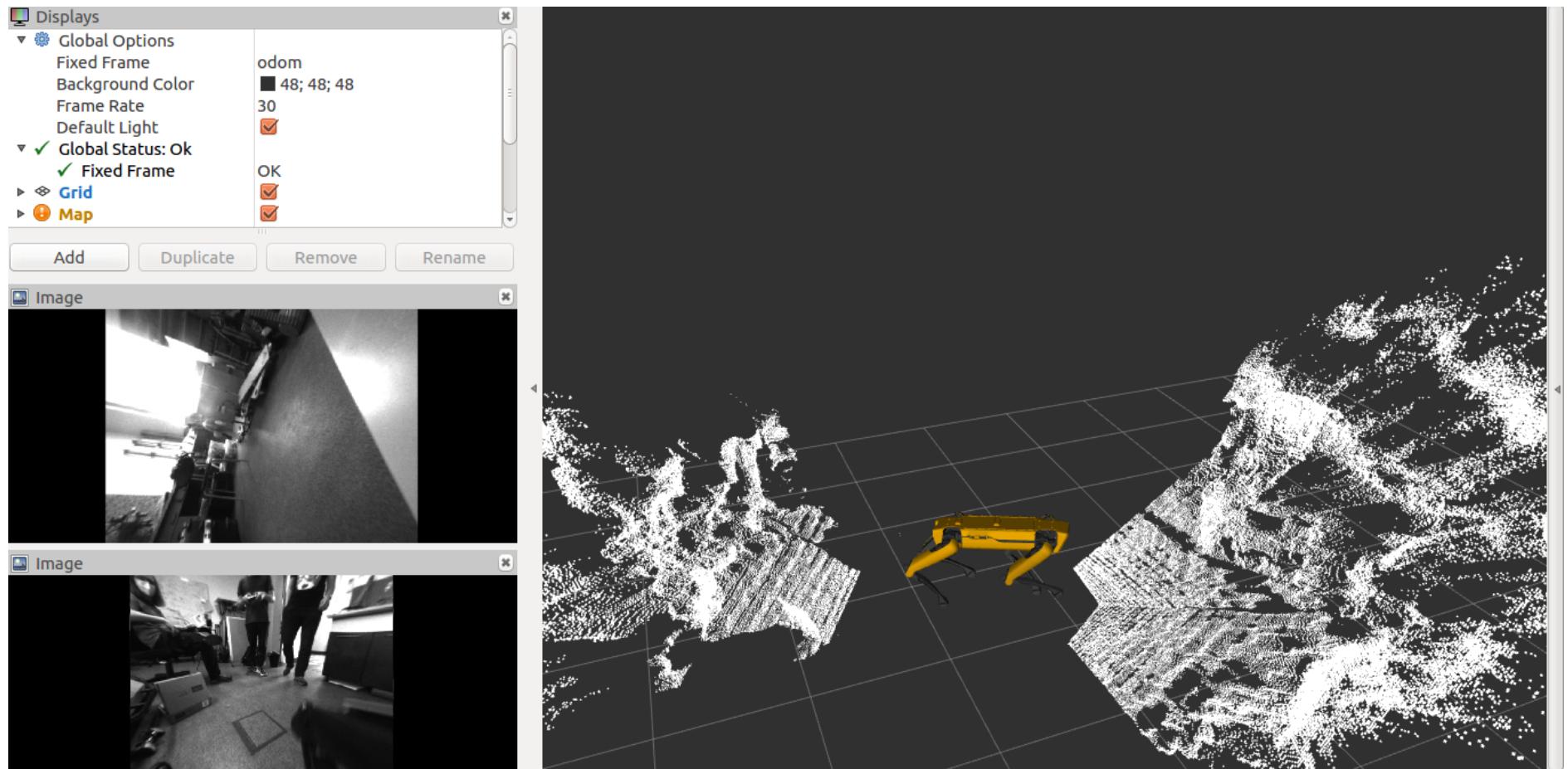
Hochschule Bonn-Rhein-Seig

Michal and Musharraf  
Based on the presentation of Divin and Santosh

# Where is Linear Algebra applied?

- Robotics
- Data Analysis
- Computer Vision

# Motivation



# **Vectors**



*y*



θ  
θ

*x*



*y*



*x*

0

0



*y*



*x*

0  
0



5  
4

3  
-2



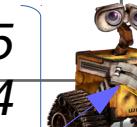
*y*



$\theta$   
 $\theta$

*x*

5  
4



$\theta = -33.7^\circ$   
 $\ell = 3.6^\circ$



$\ell \cos(\theta)$   
 $\ell \sin(\theta)$

# **Vector Operations**

*y*



*x*



*y*



*x*

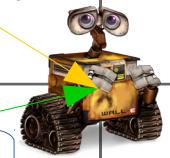
0  
0



5  
4

3  
-2

8  
2



*y*



*x*

0  
0

*y*

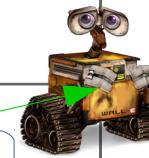


*x*

0  
0

8

2



θ  
θ

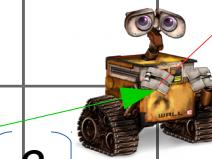
*y*



*x*



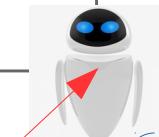
*x*



8  
2

$\ell=5.65$

$\theta=45^\circ$



?  
?

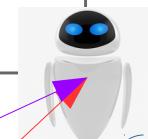
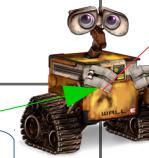
*y*



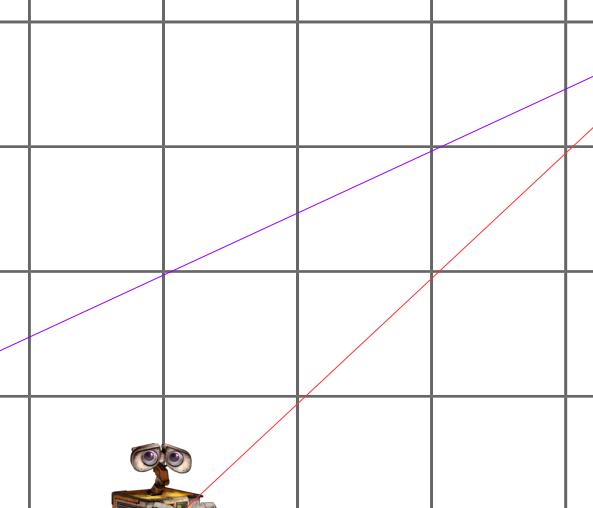
*x*

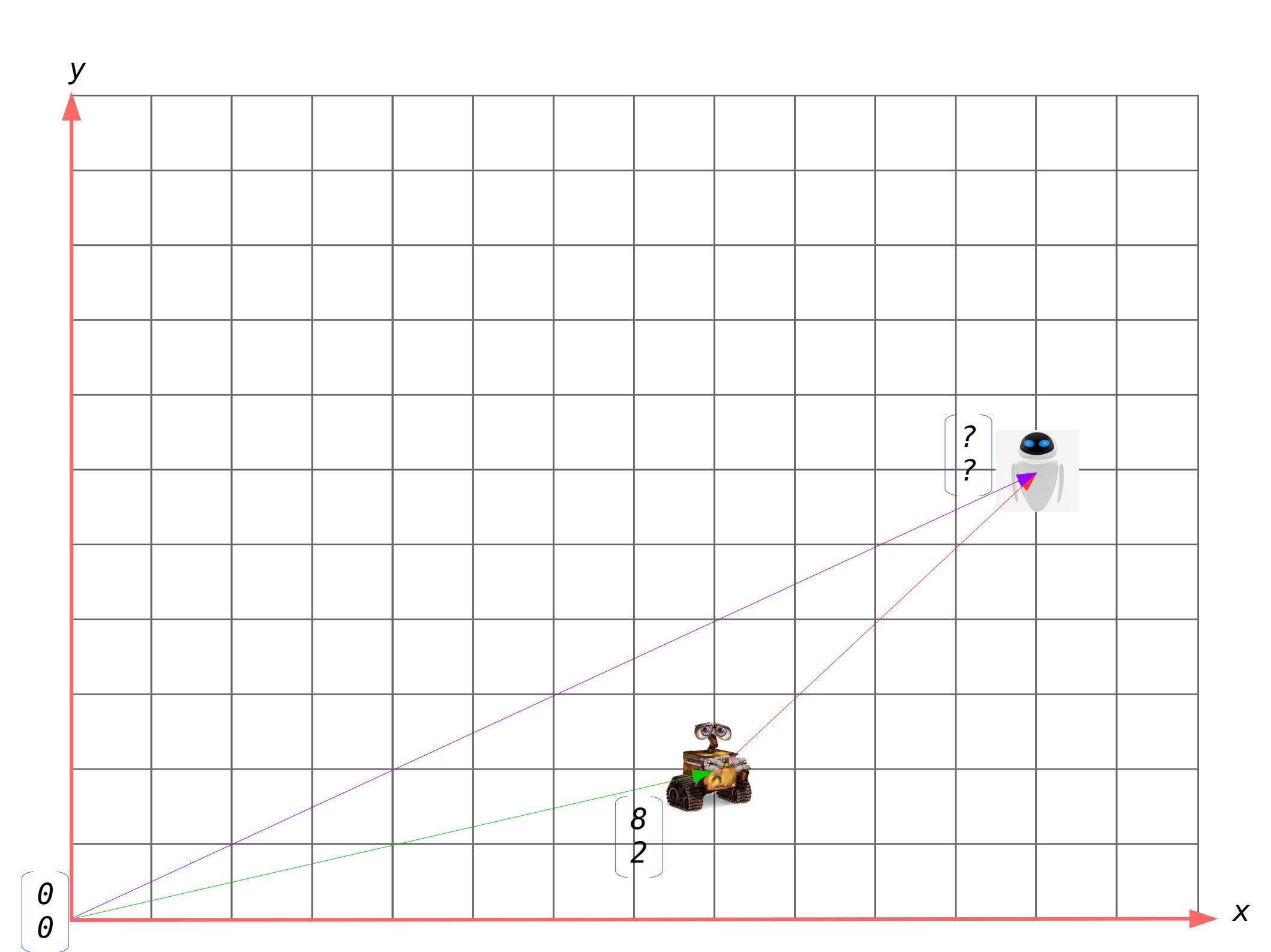
0  
0

8  
2



?  
?



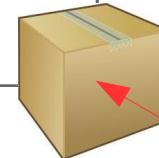


*y*

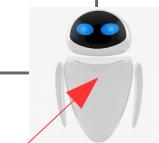
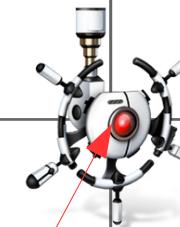
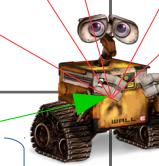


*x*

0  
0



8  
2

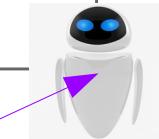
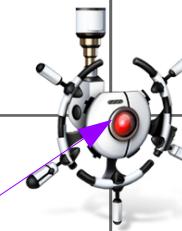
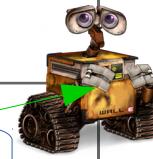
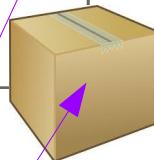


*y*



*x*

0  
0



8  
2

0  
0

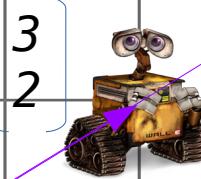
# Scaling

*y*



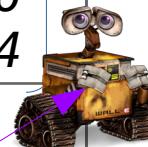
*x*

$\theta$   
 $\theta$



3  
2

6  
4

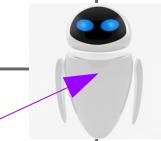
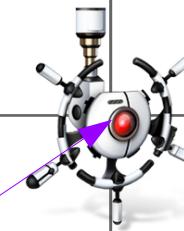
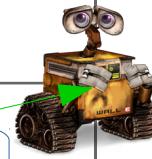
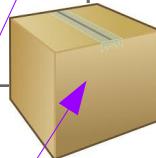


*y*



*x*

0  
0



8  
2

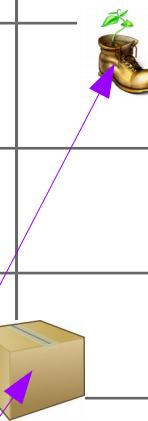
0  
0

*y*



*x*

0  
0



0  
0



# Basis Vectors

*y*



*x*

$\theta$   
1

$\theta$   
 $\theta$

1  
 $\theta$

5  
4





# **Linear Combination**

*y*



$\theta$   
 $\theta$

*x*

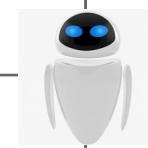
# **Matrix**

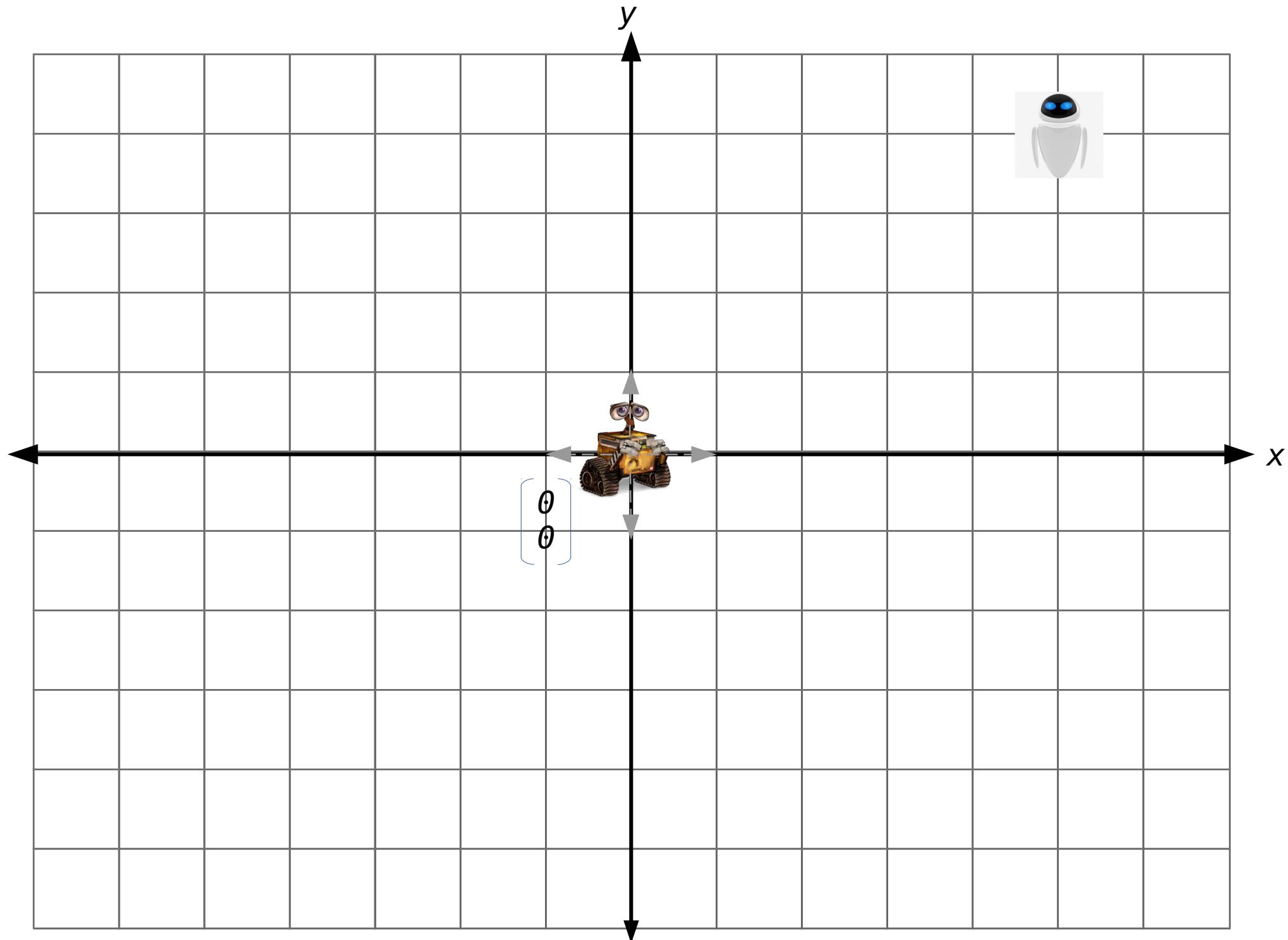
*y*

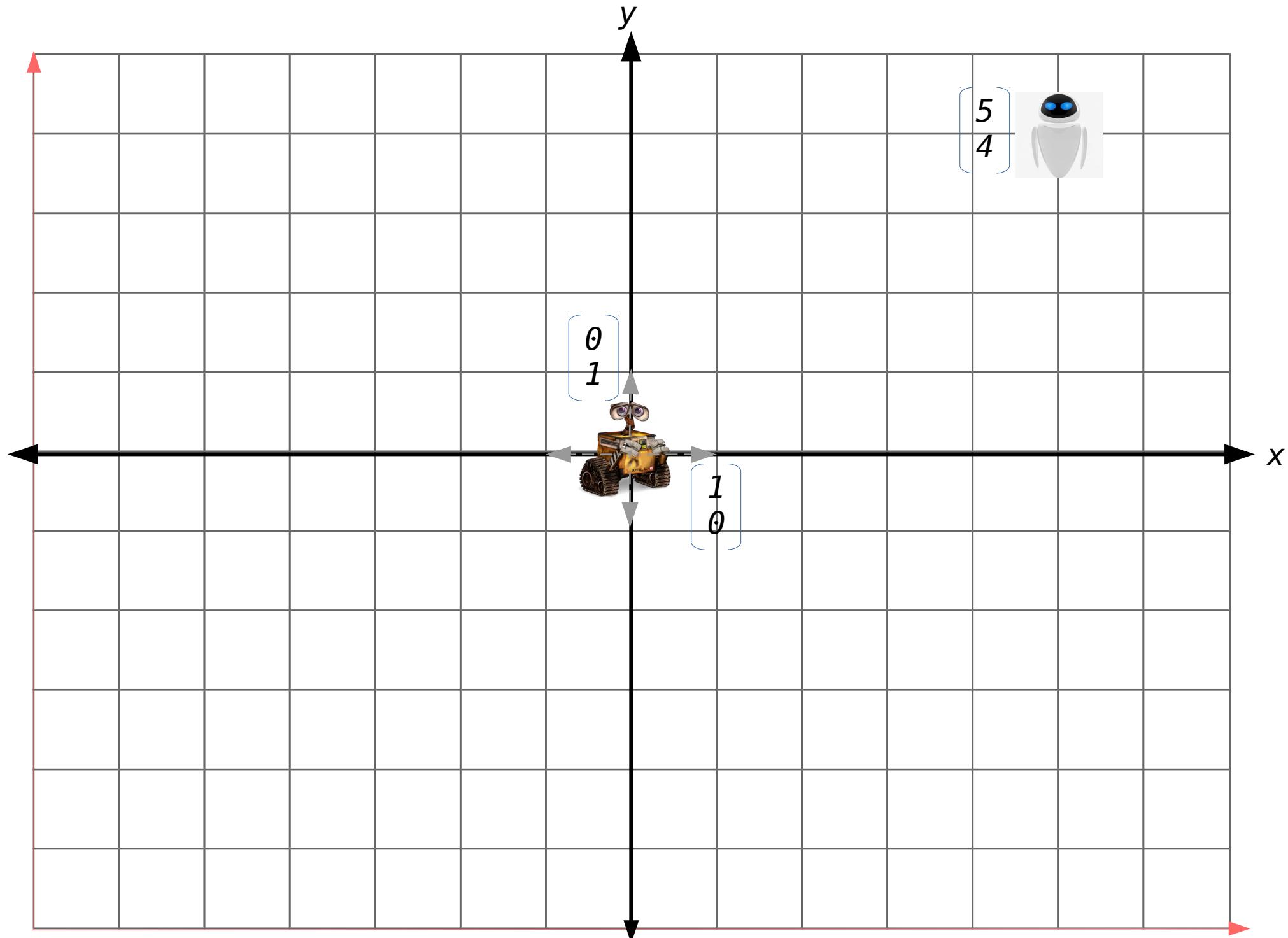


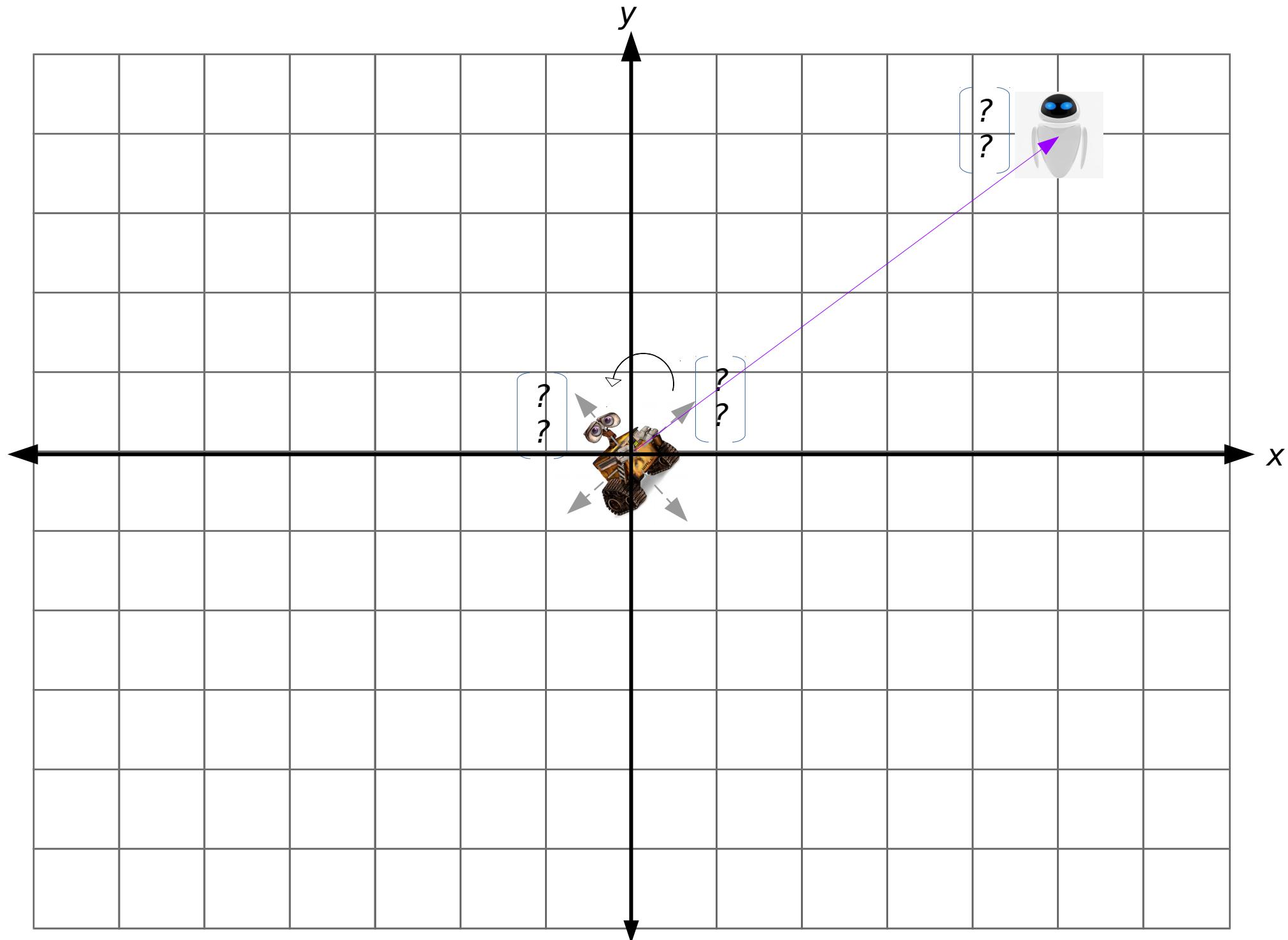
$\theta$   
 $\theta$

*x*



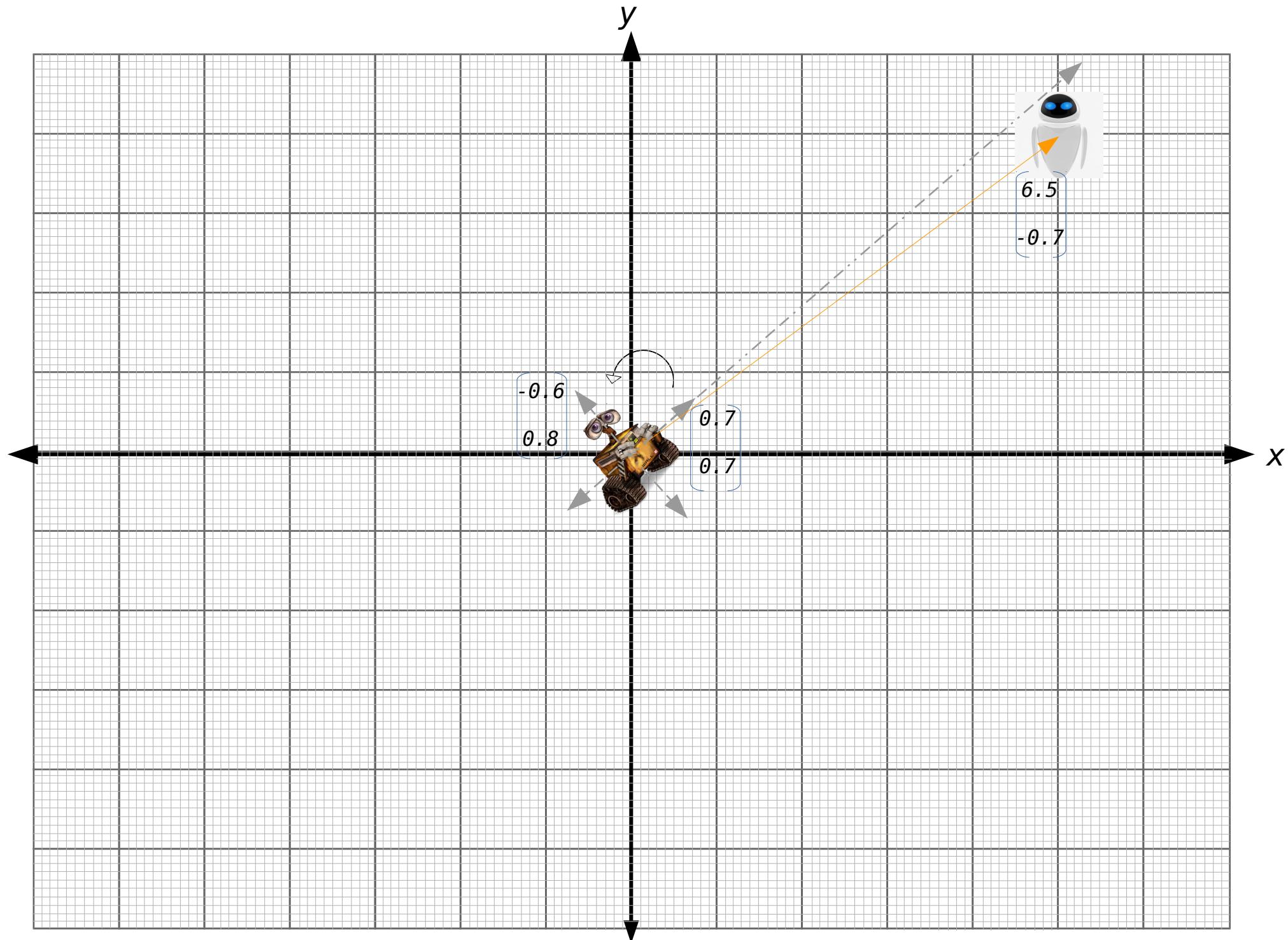






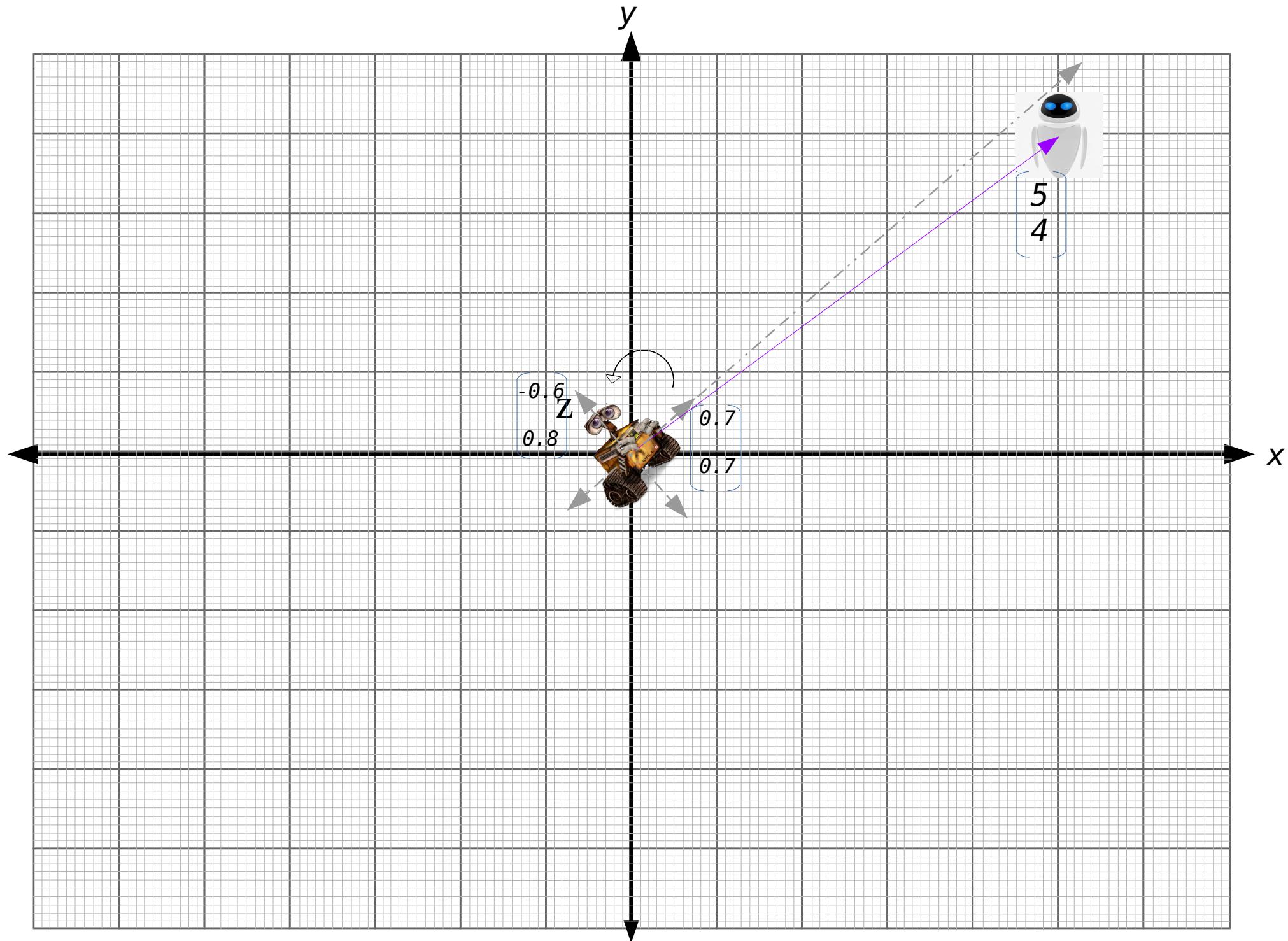
# **Matrix Multiplication**



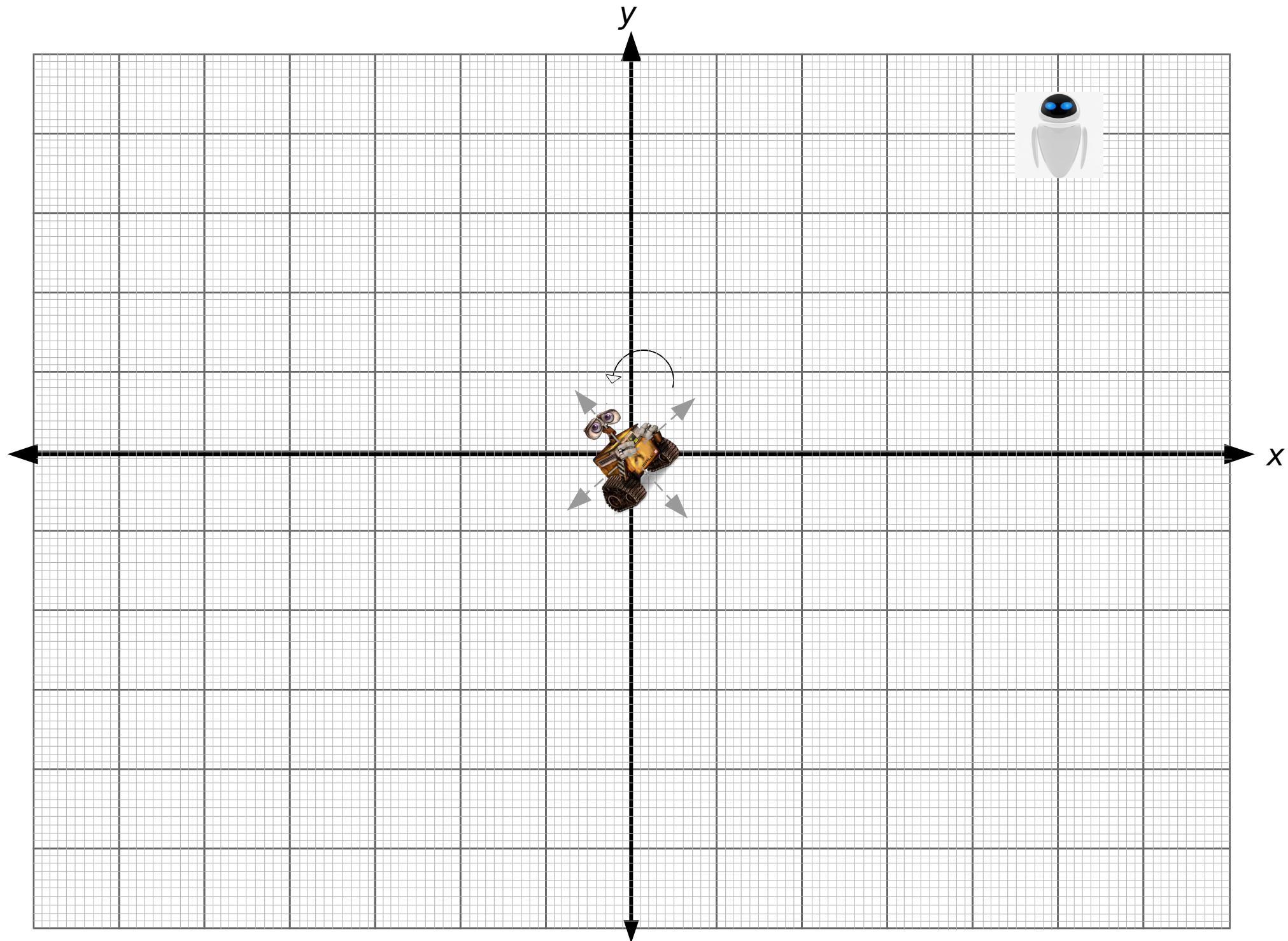


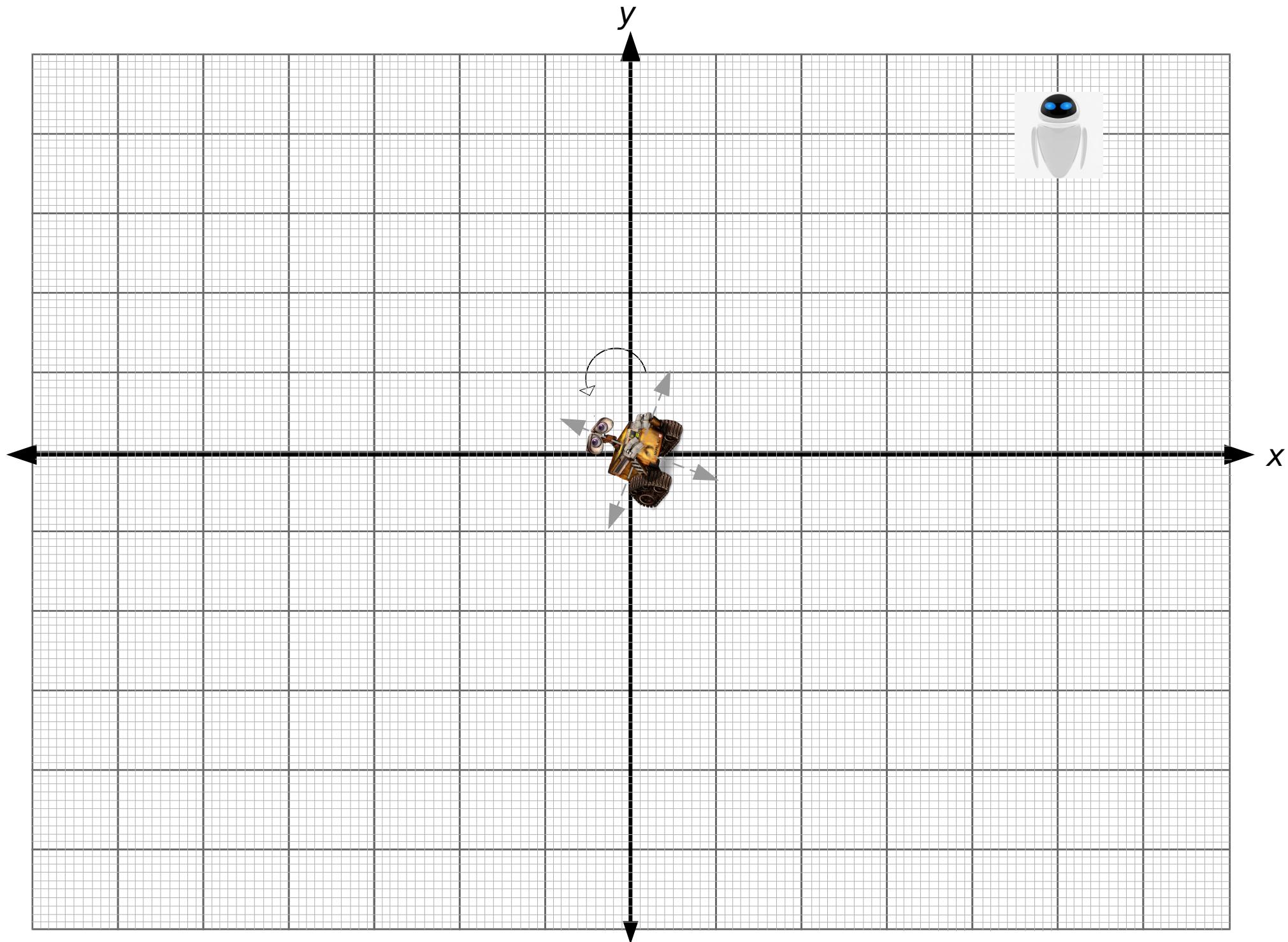
# **Inverse of a Matrix**





# **Composition**

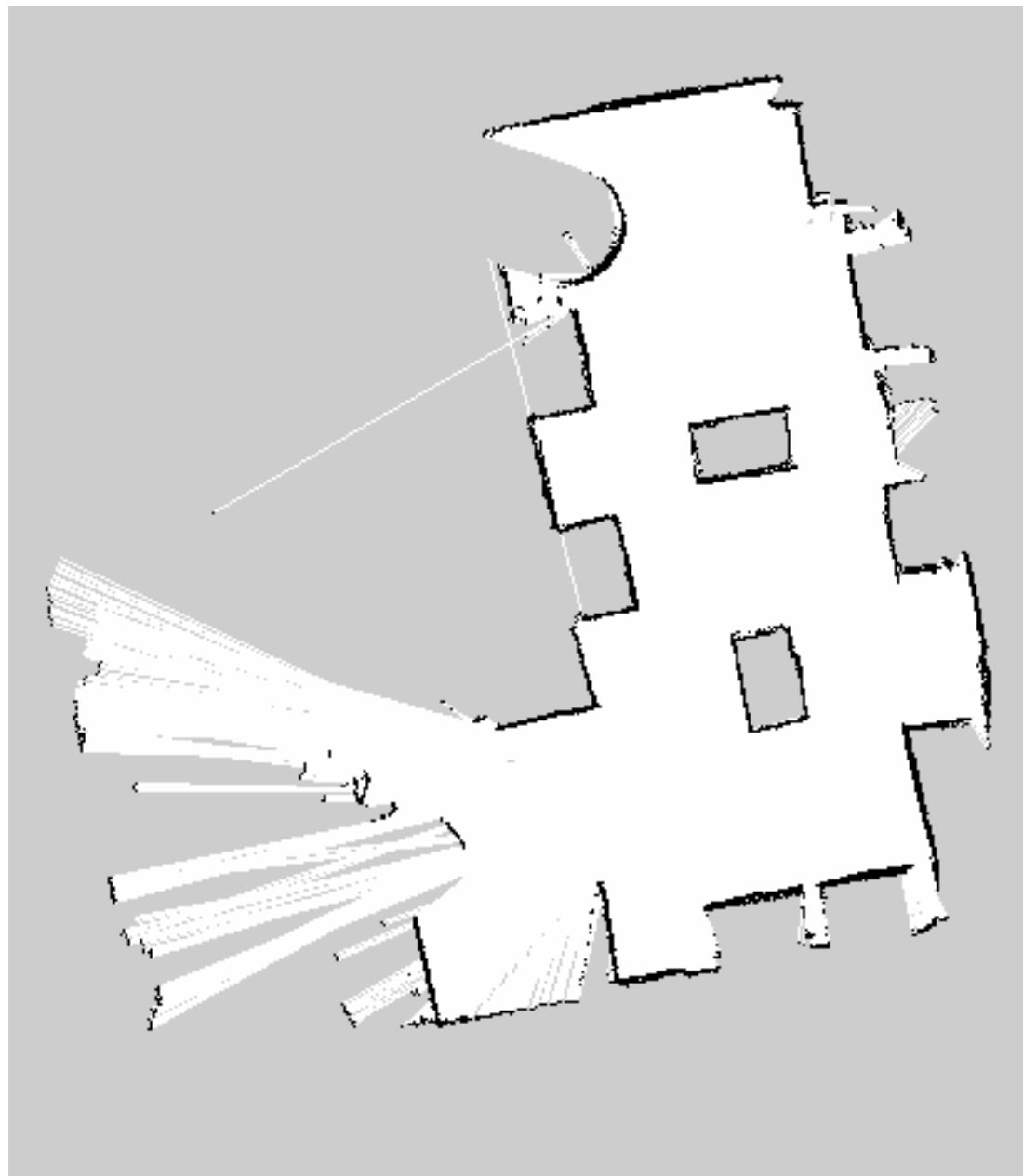


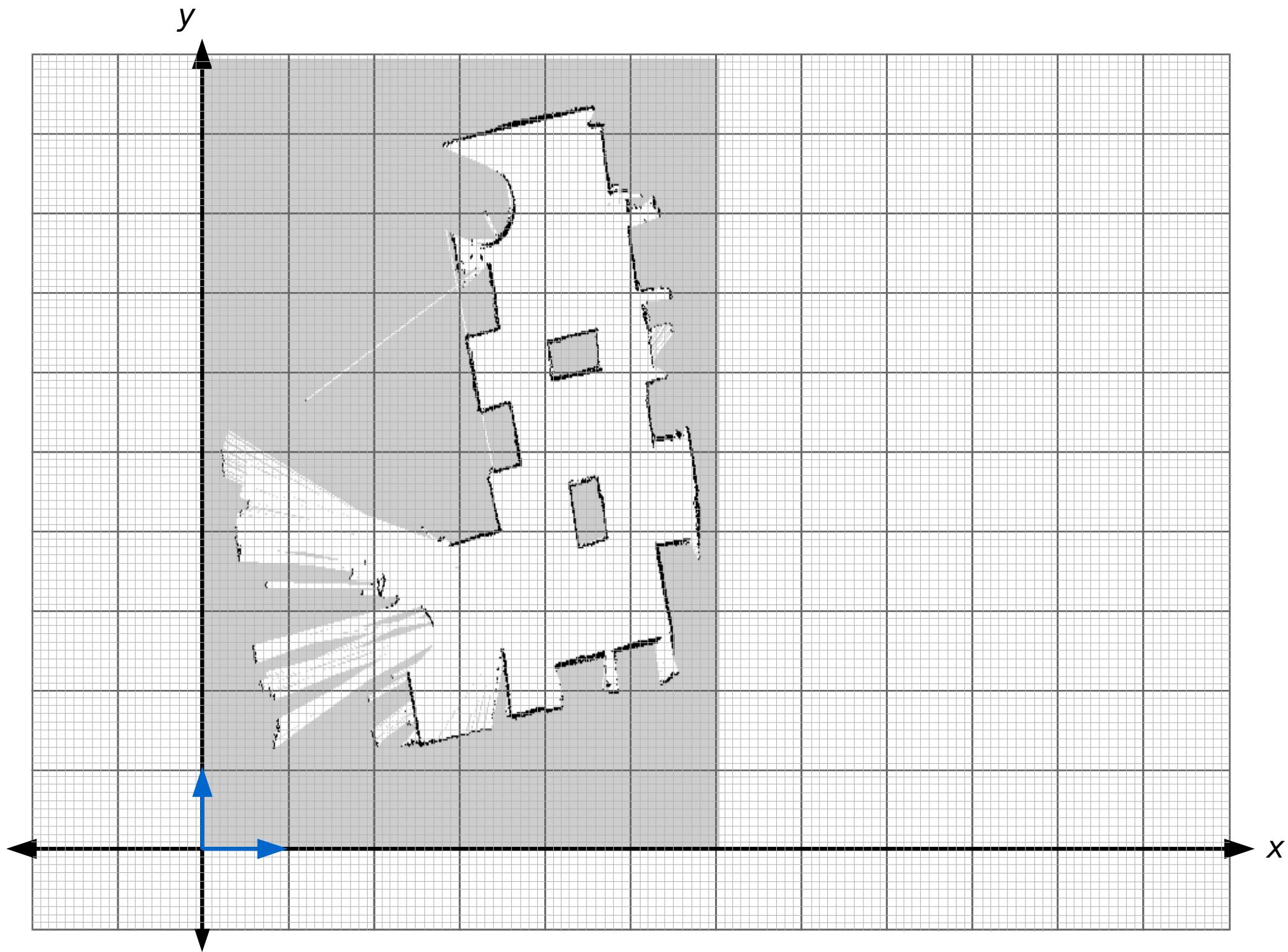




# Applications

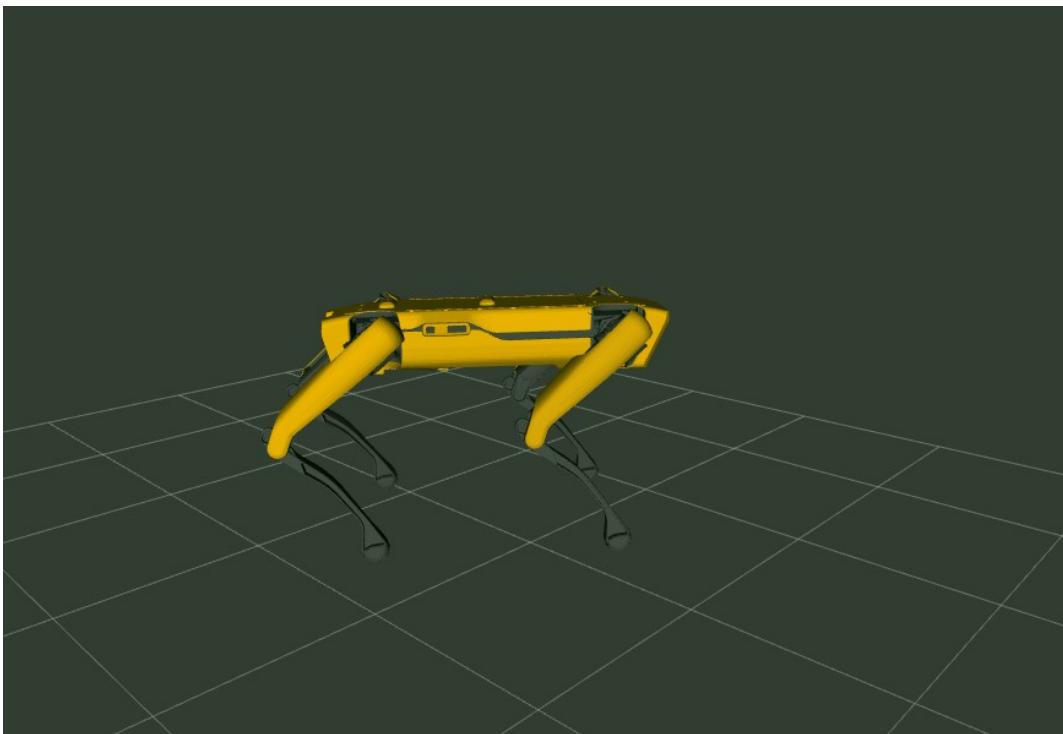
Robotics: Mapping





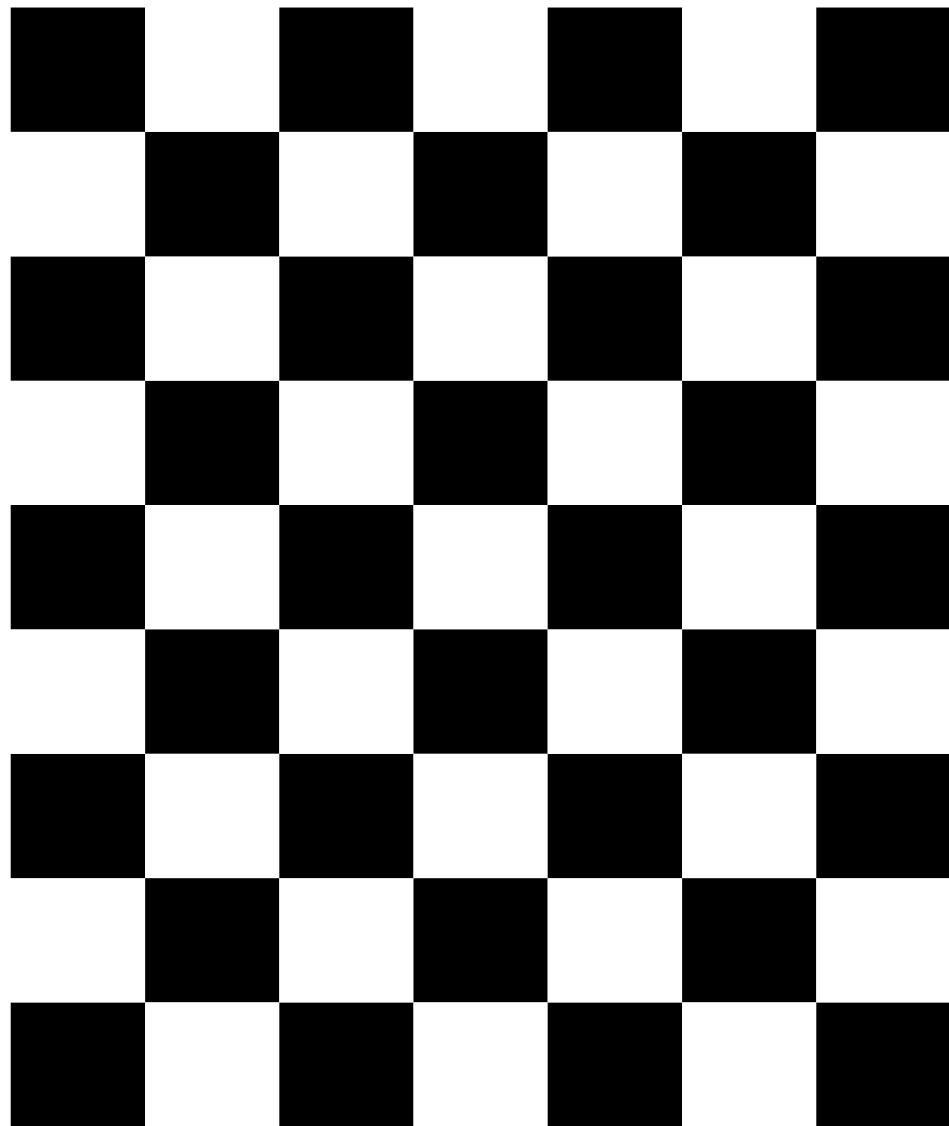
# Applications

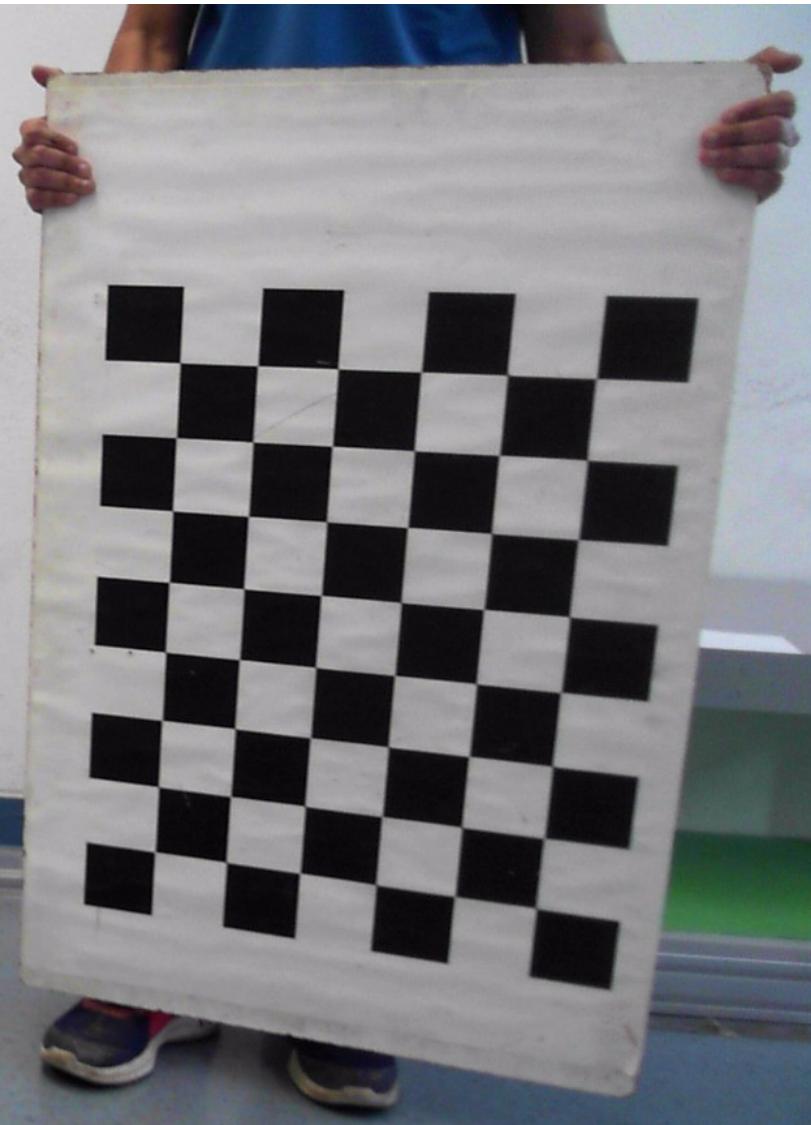
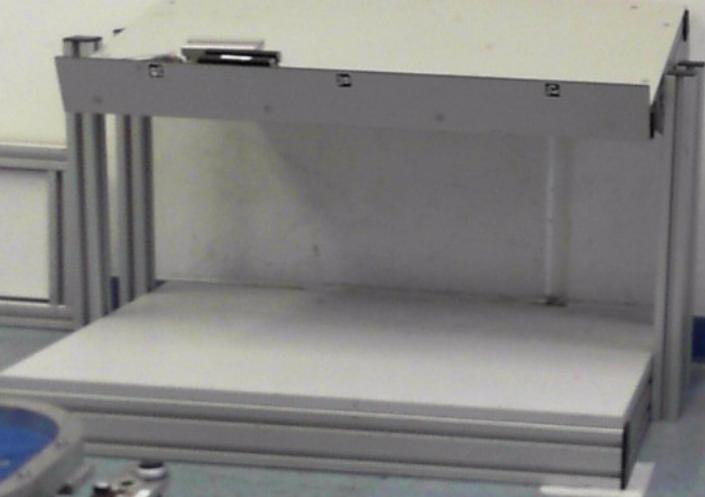
Robotics: Robot Control

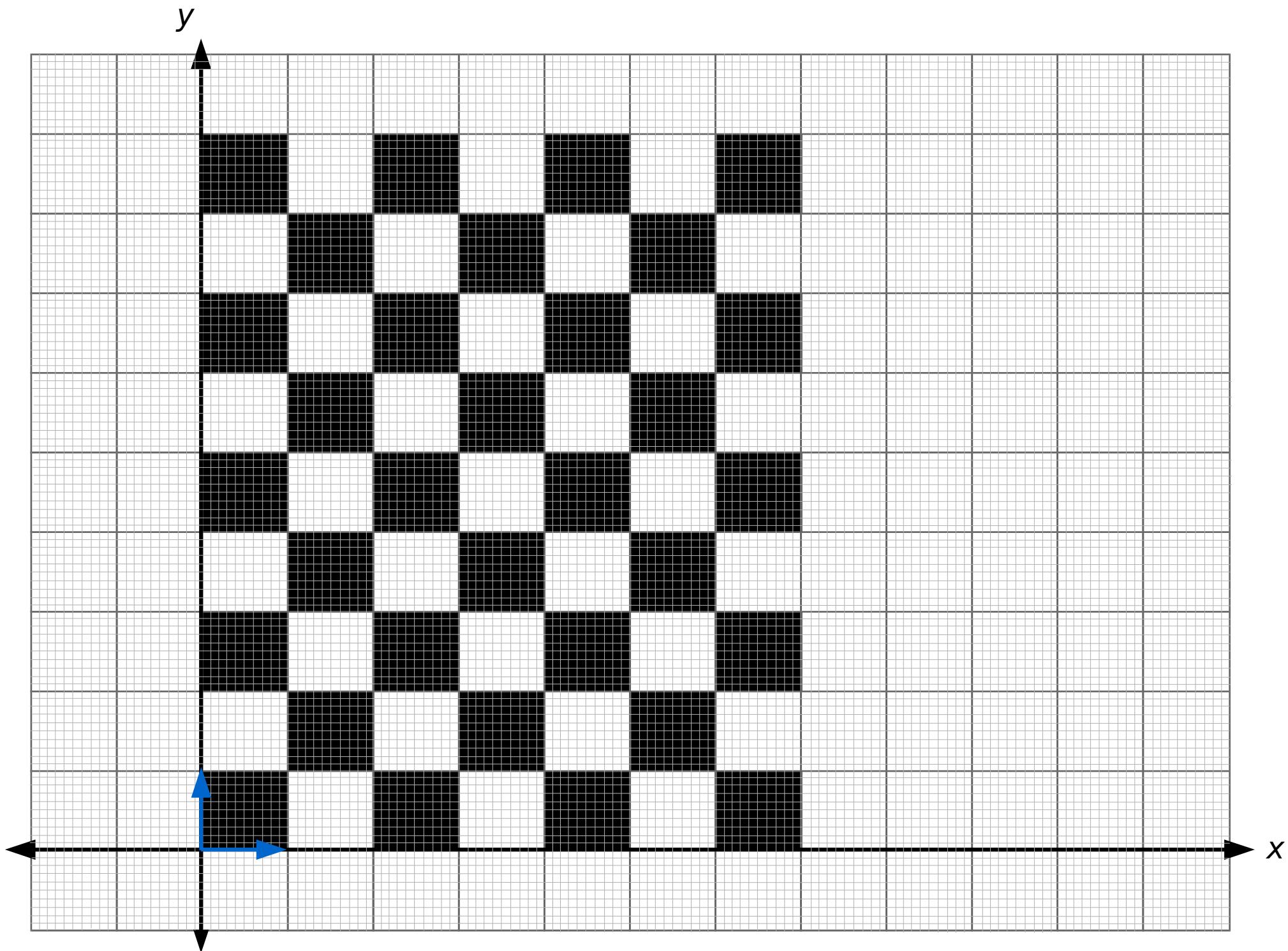


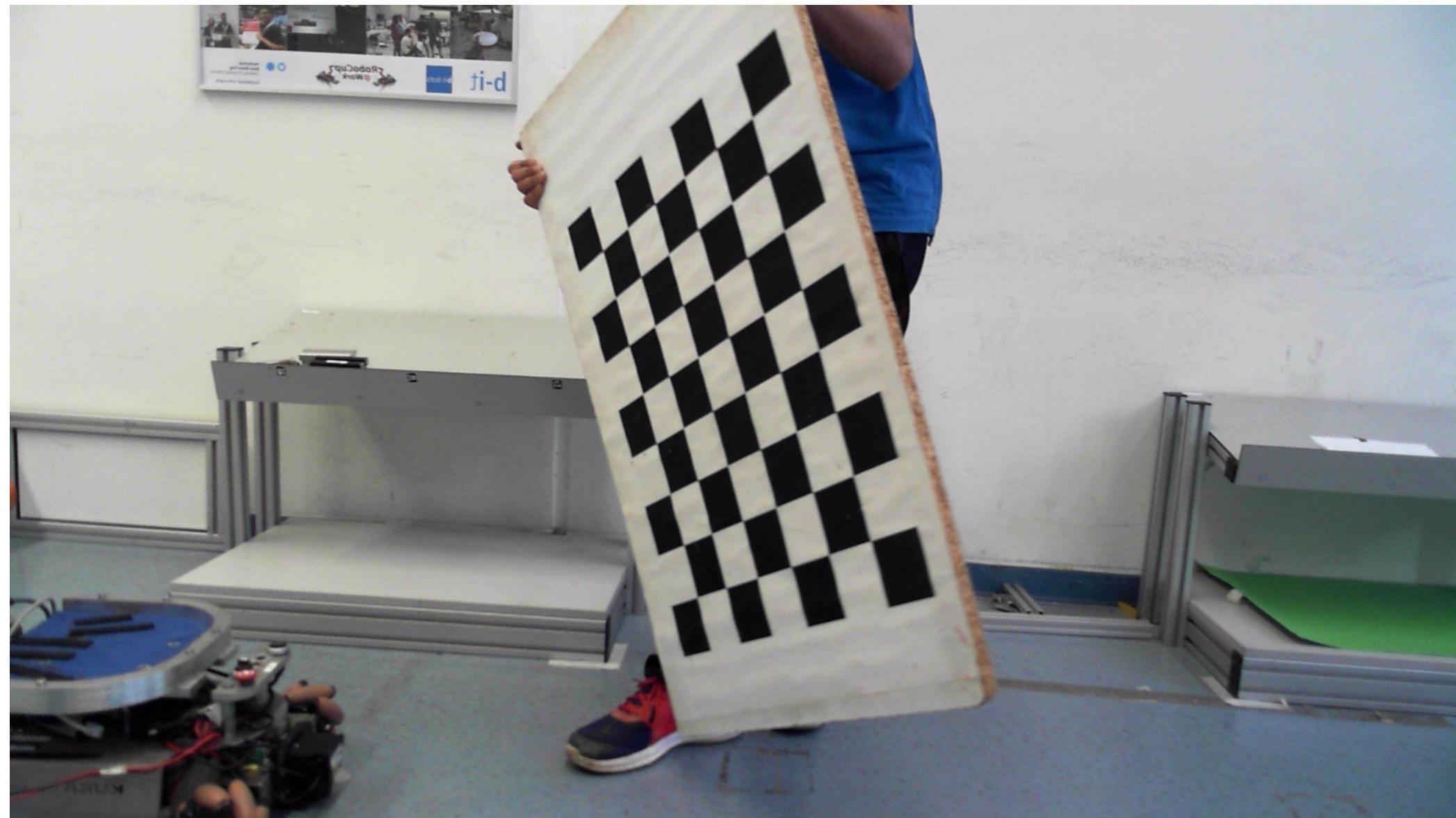
# Applications

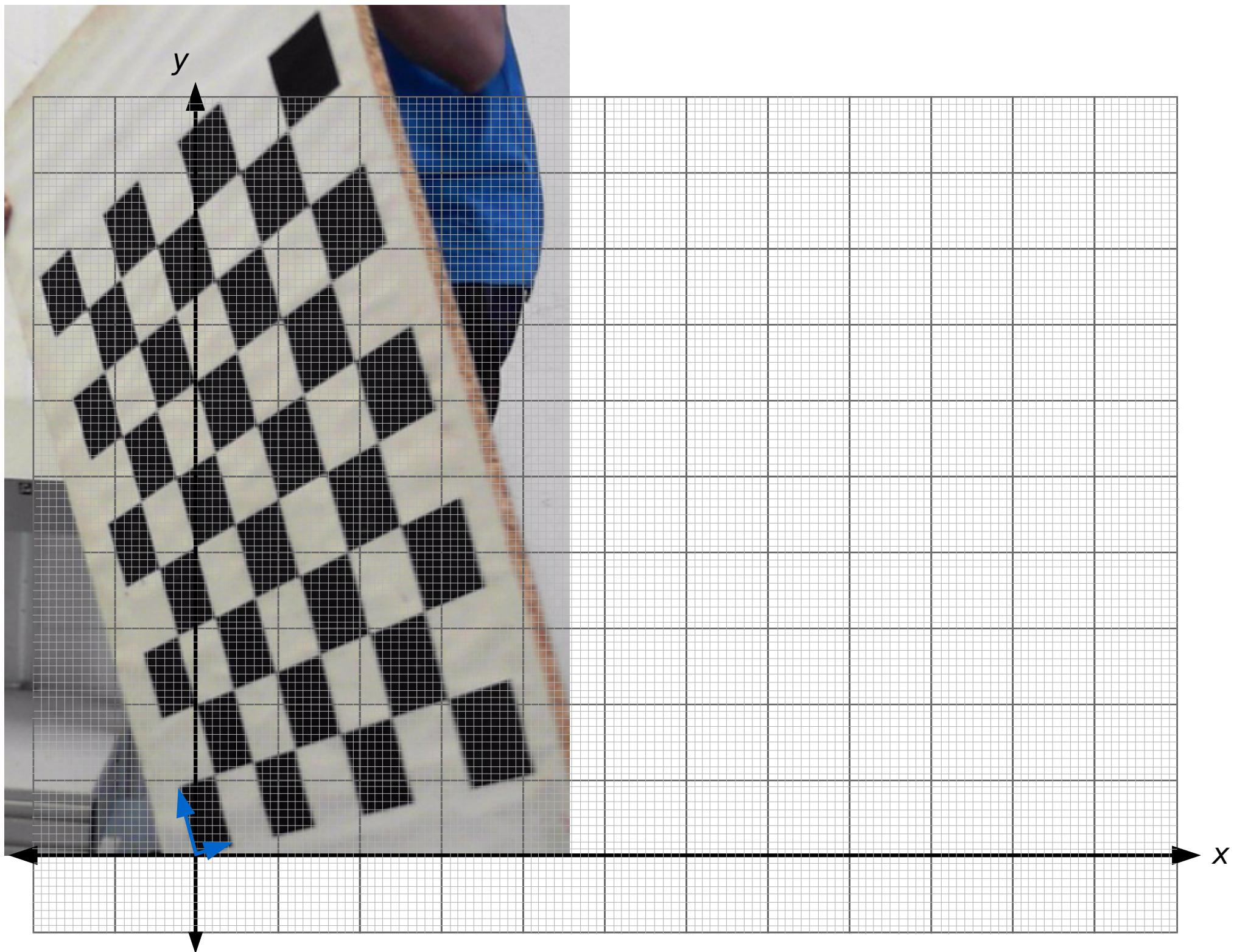
Computer Vision

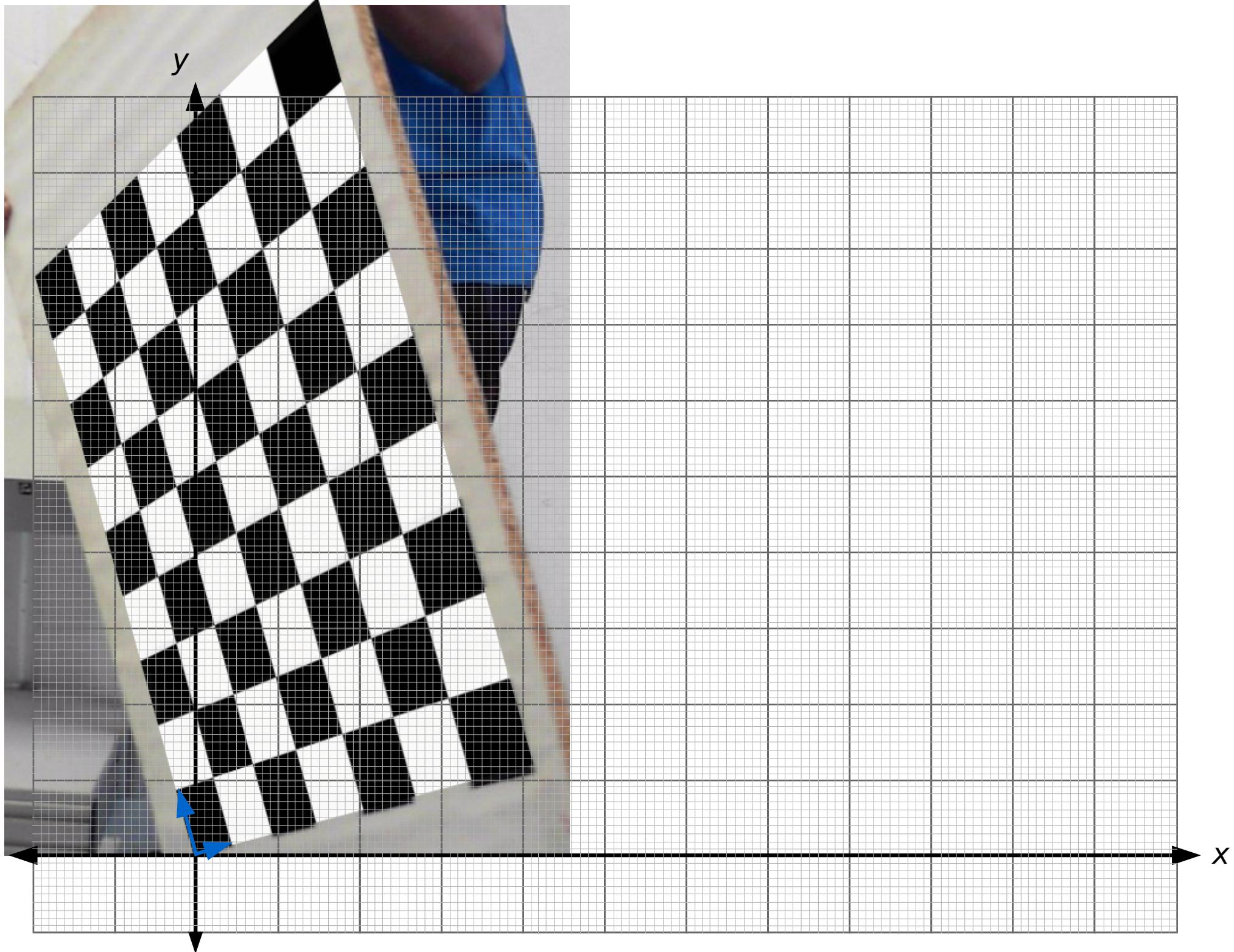


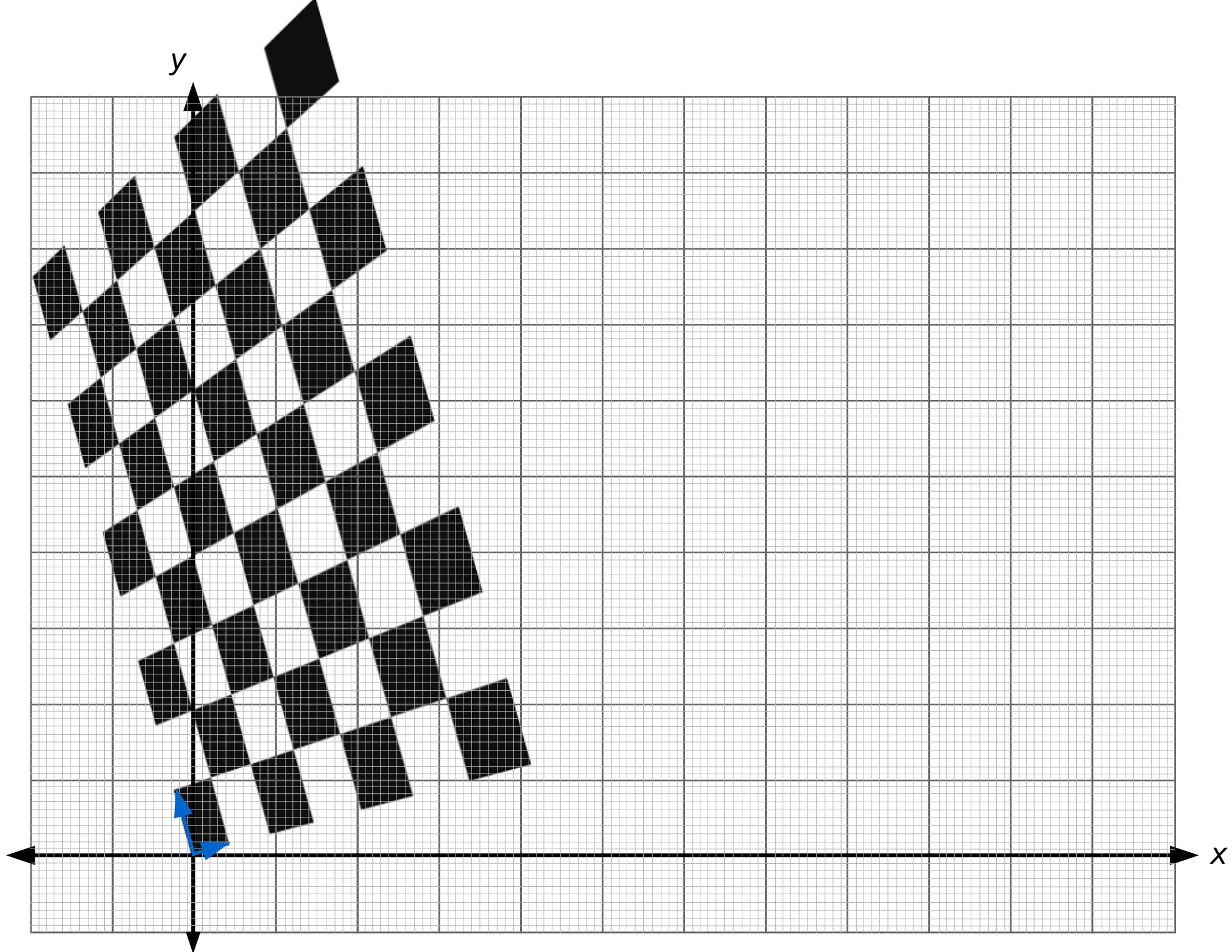






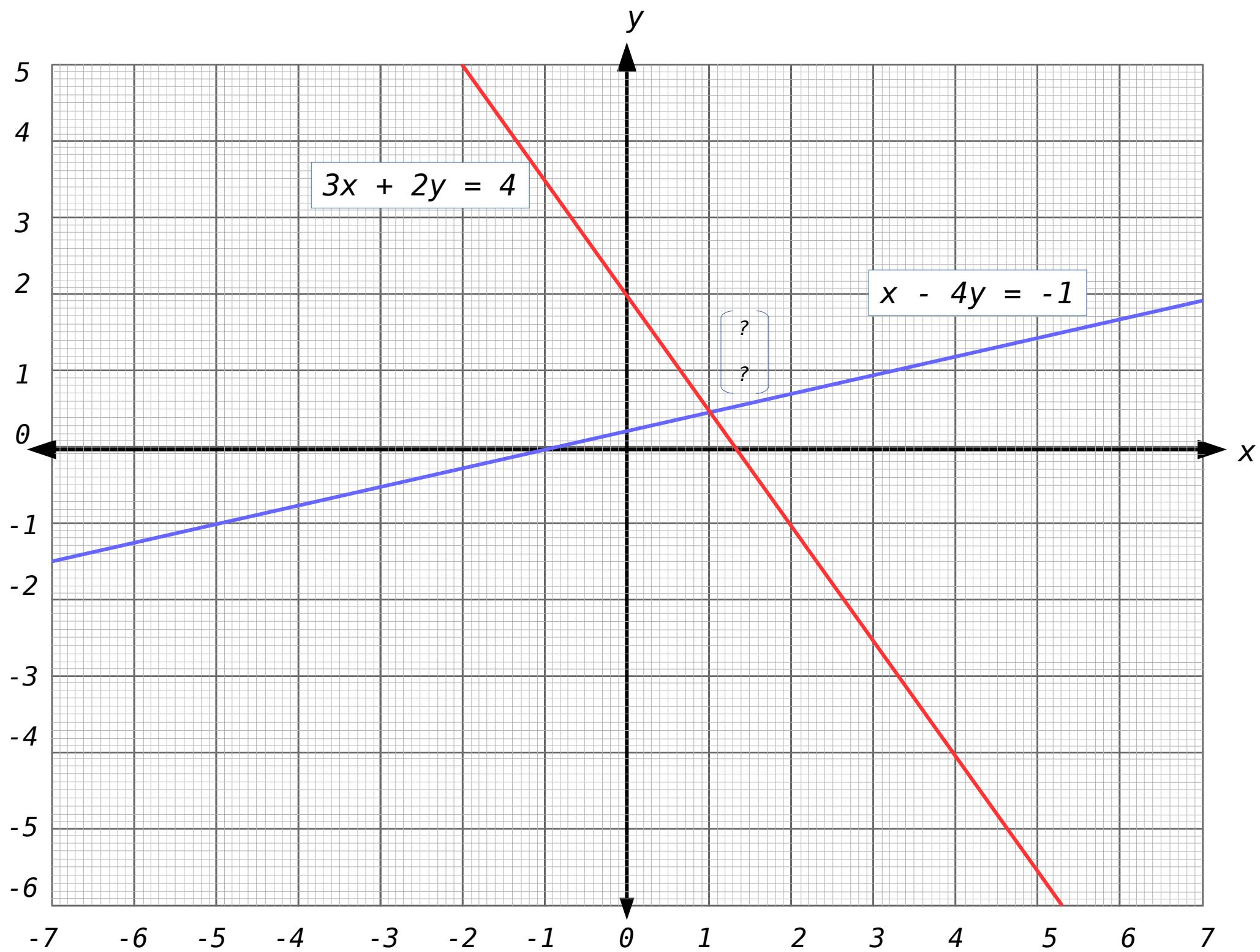






# Applications

System of Equations





# Determinant

*y*



$\theta$   
 $\theta$

*x*



# **Rank of Matrix**

*y*



*x*

θ

θ



# **Null and Column Space**

*y*



$\theta$   
 $\theta$

*x*

