Simulation microscopique de foule grâce aux forces sociales en respectant les contraintes de distances sanitaires

GENEST
Hugo
Numéro d’inscription : 46185

3 Étapes :

I. Déplacement d’un individu seul

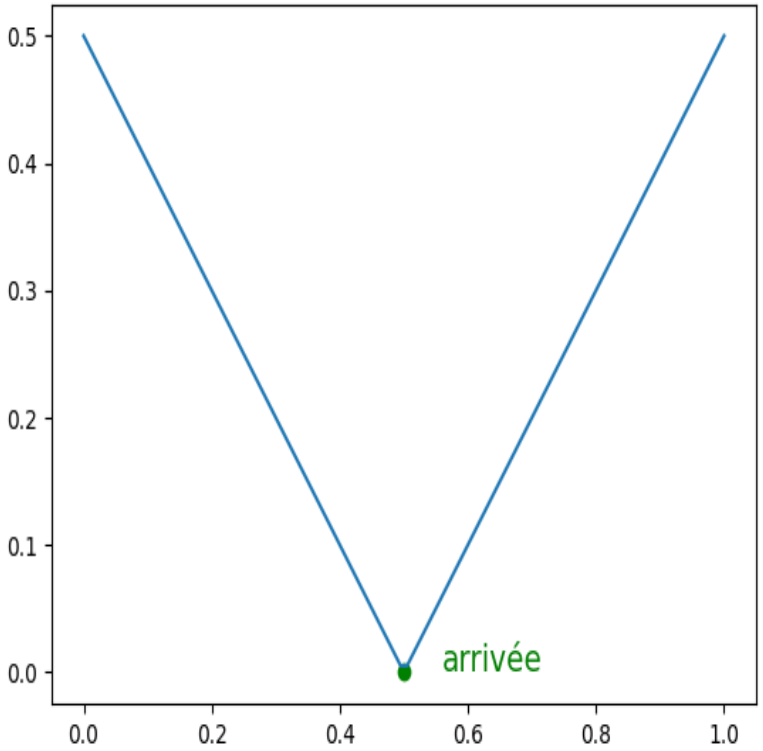
II. Déplacement de plusieurs individus

III. Prise en compte de la distanciation sociale

I. Déplacement d'un individu seul

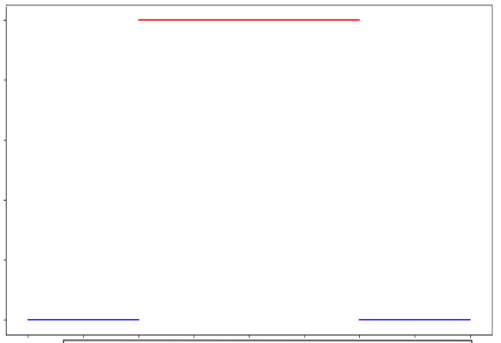
a. Concept de potentiel

- **Points Attractifs**

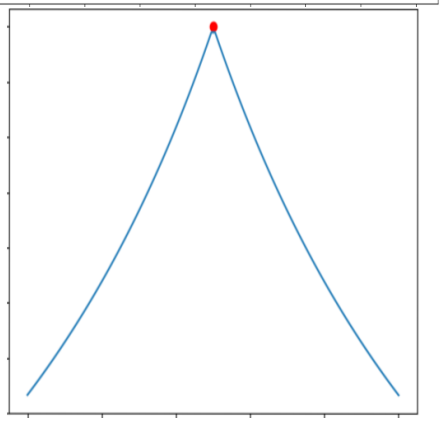


- **Points Répulsifs**

 # plateau :

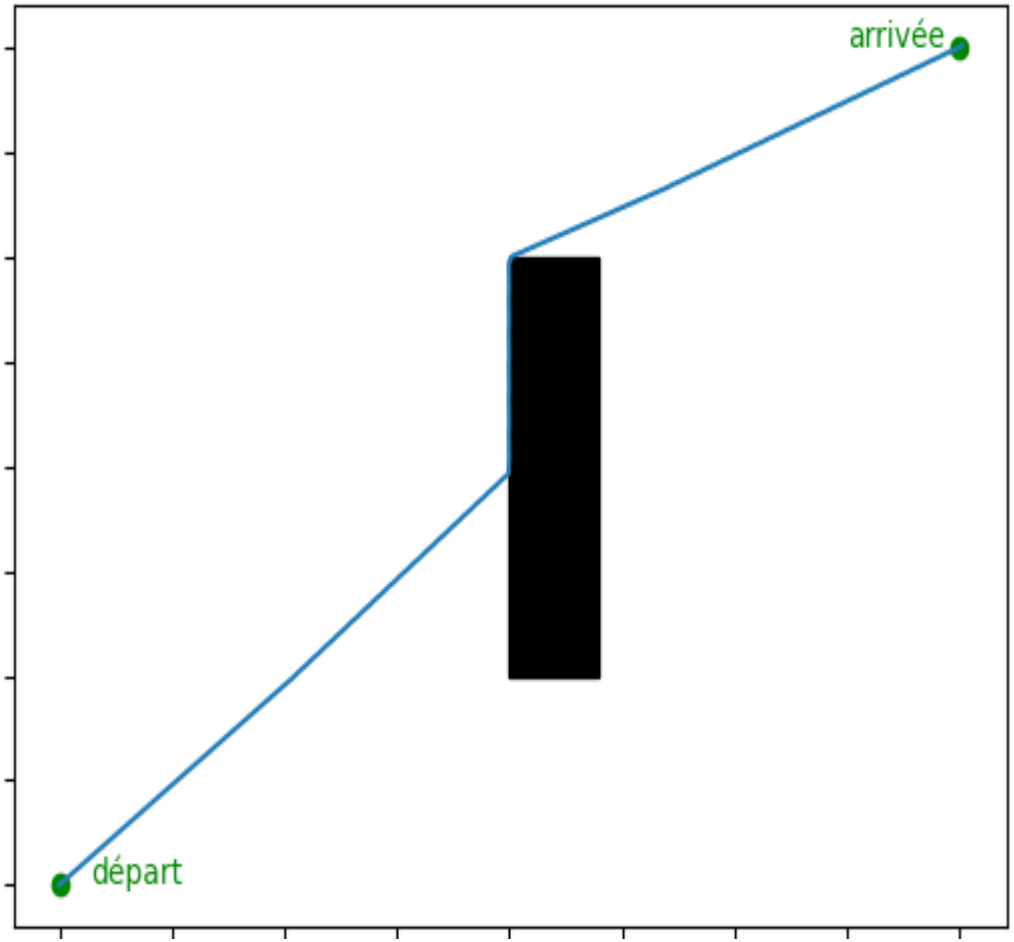


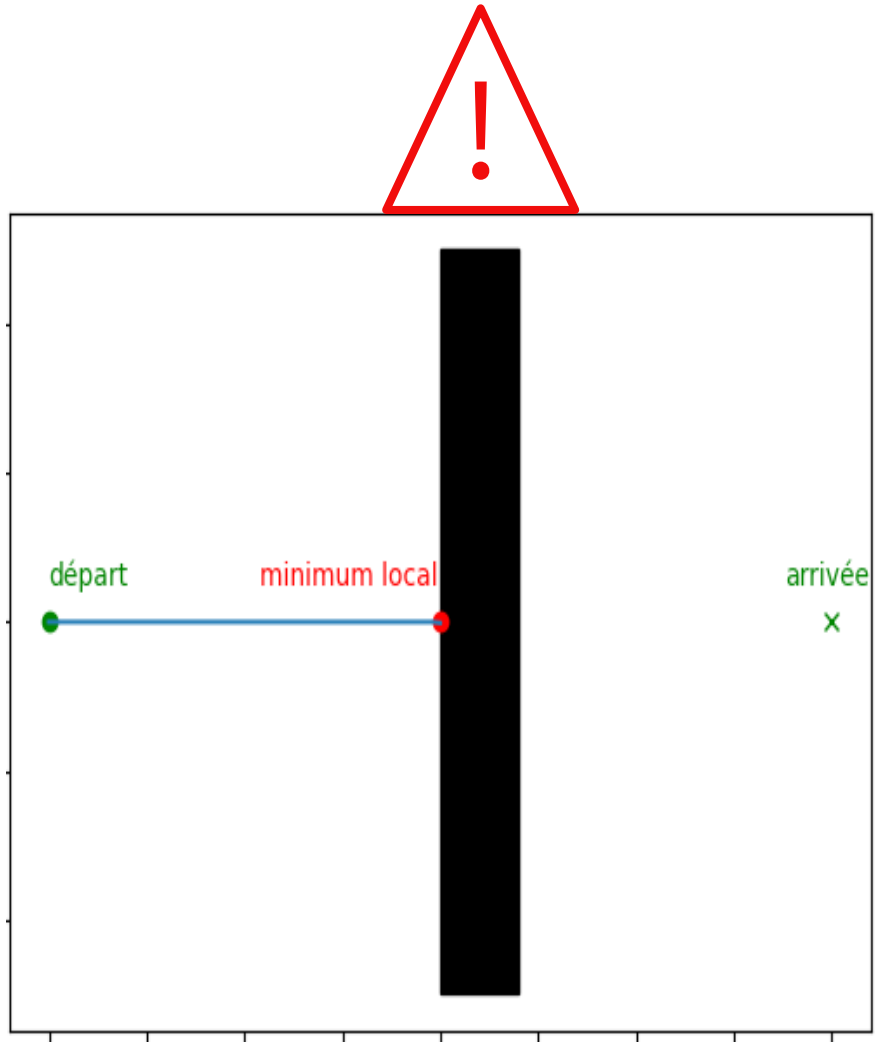
 # 1/(1+dist) :



I. Déplacement d'un individu seul

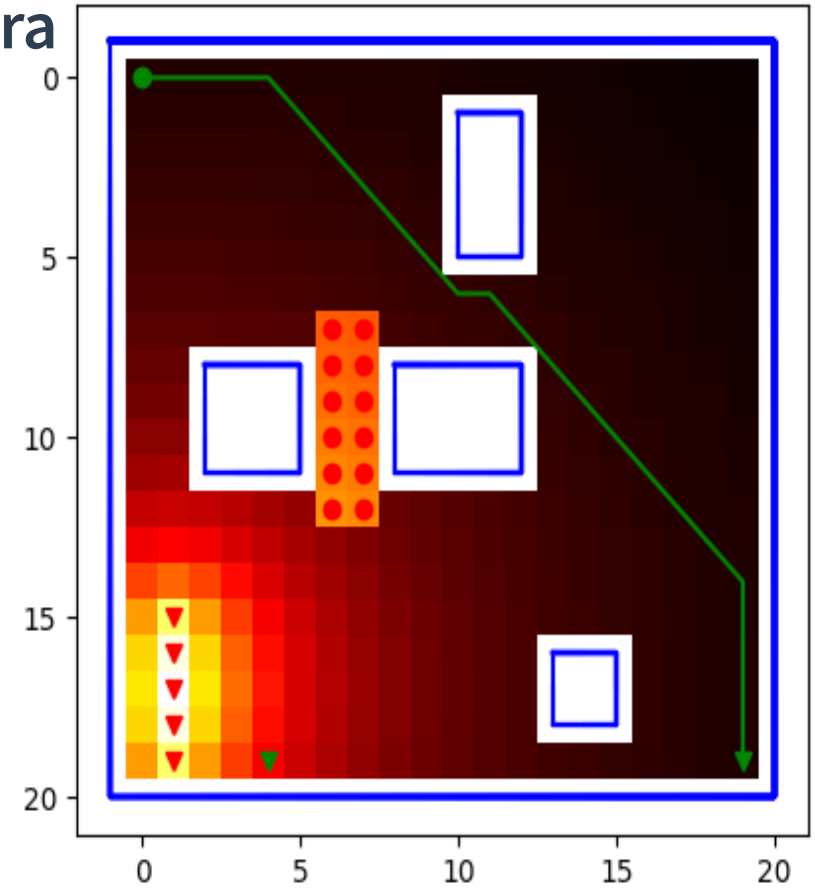
b. Descente du gradient





I. Déplacement d'un individu seul

c. Dijkstra



Départ

Arrivées

Point répulsifs :

potentiel plateau

potentiel inverse

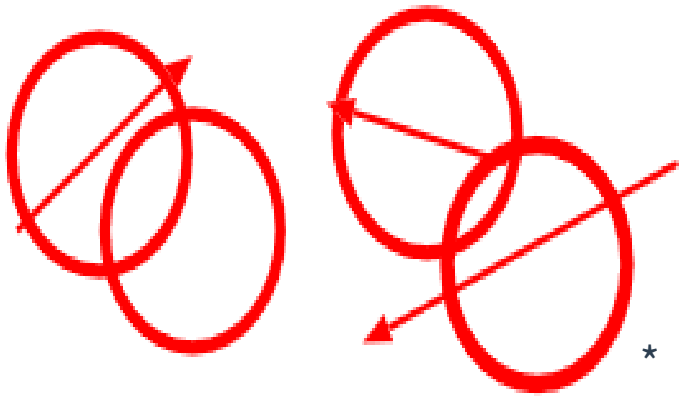
Hauteur du potentiel

Poids = importance_deplacement*distance + importance_potent*potentiel

II. Déplacement de plusieurs individus

Objectif : Pouvoir utiliser l'algorithme d'Uzawa :

Vitesses Souhaitées

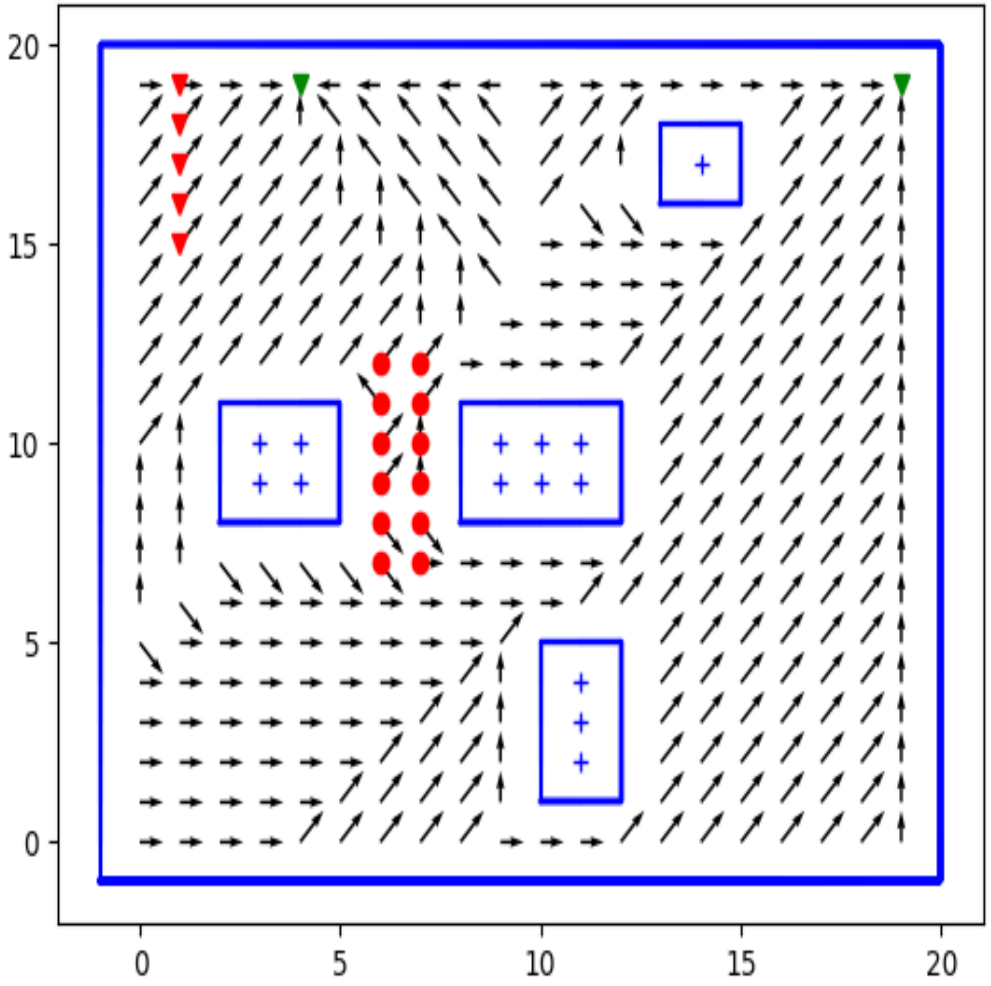


Vitesses Réelles

* Image issue de docs.gdrfeux.univ-lorraine.fr/Niort1/Orsay01.pdf, Bertrand Maury

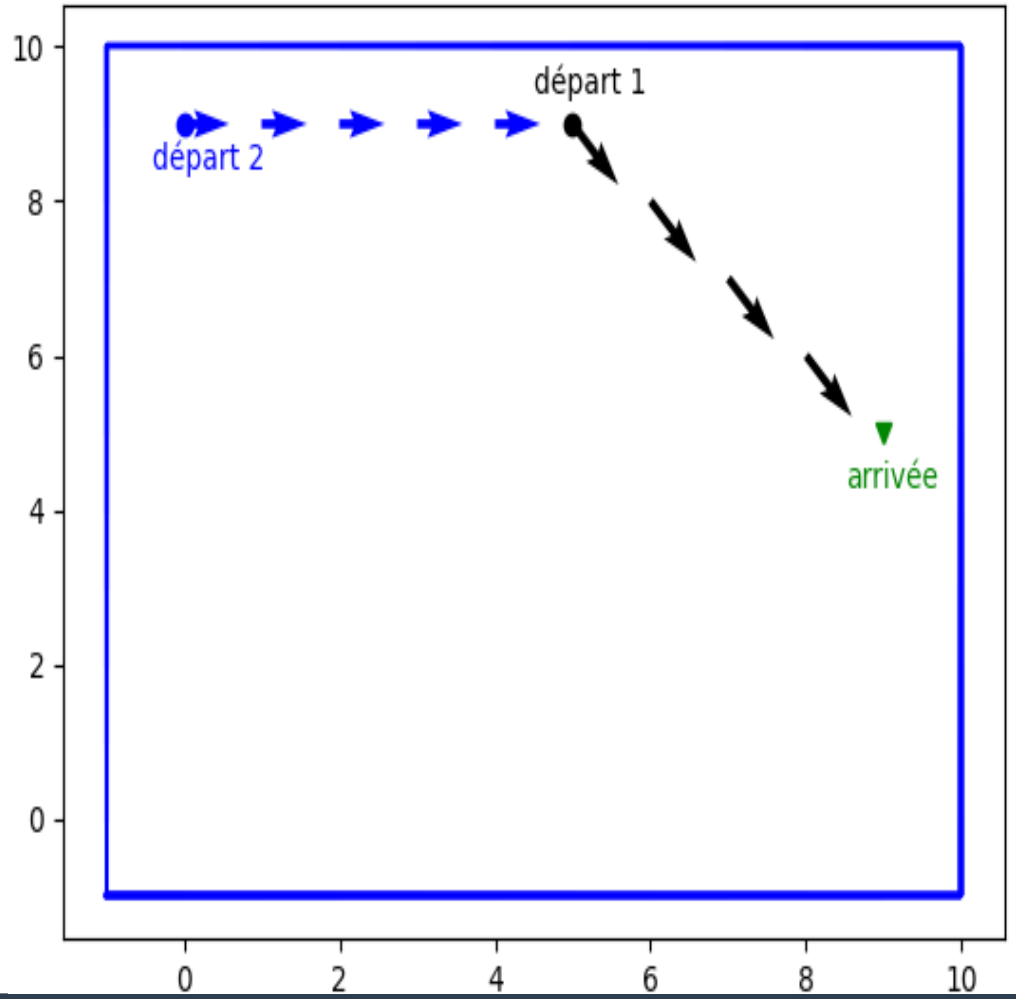
II. Déplacement de plusieurs individus

a. Directions souhaitées



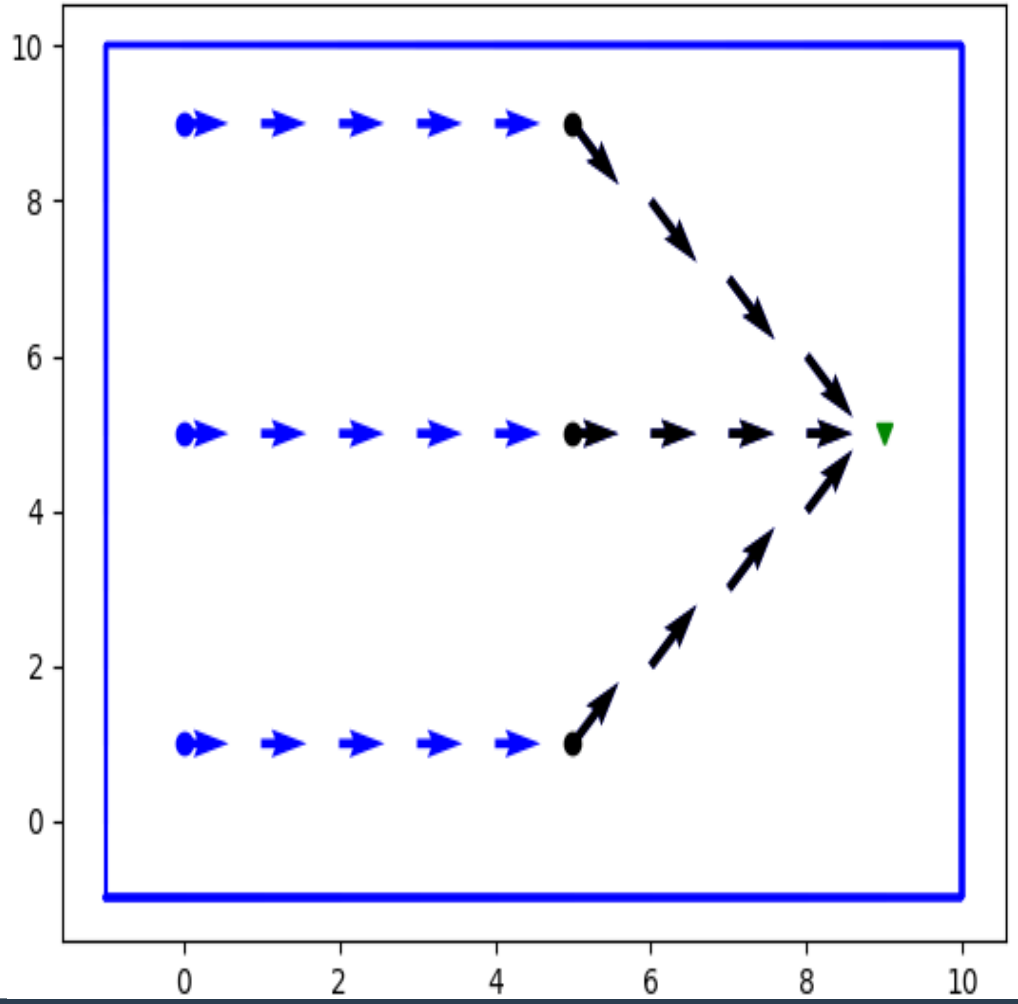
II. Déplacement de plusieurs individus

a.1. Pas de fléchage inutile



II. Déplacement de plusieurs individus

a.2. Plus de fléchage, moins de Dijkstra

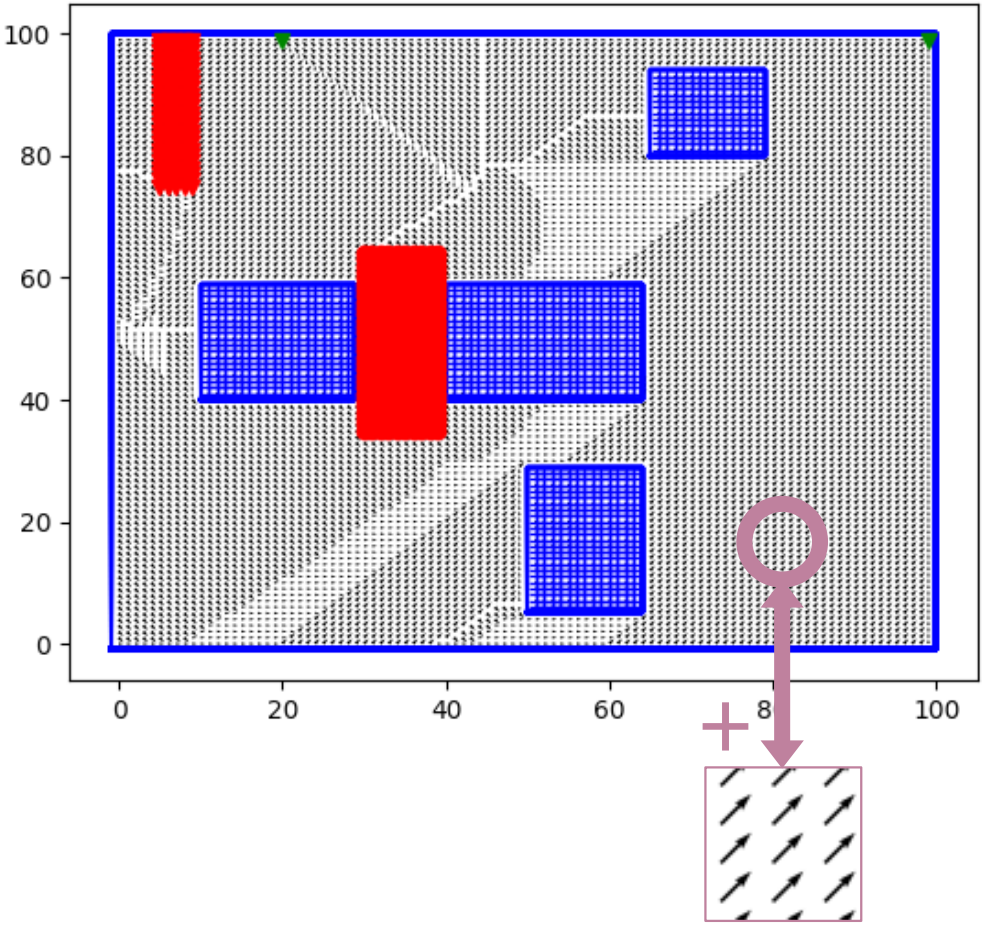


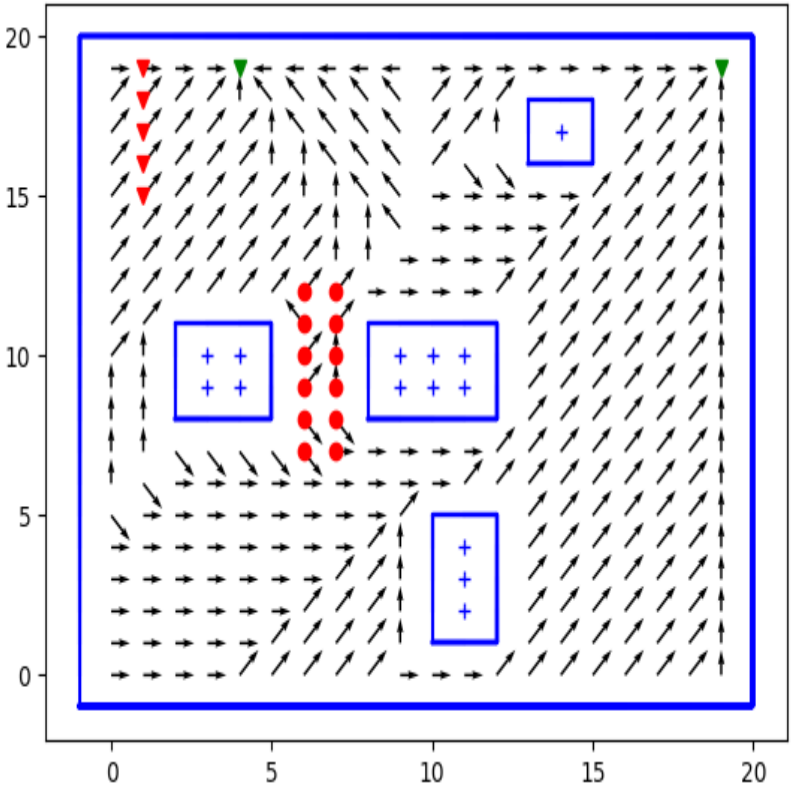
3 itérations de l'algorithme de Dijkstra :

- **13 points fléchés**
- **28 points fléchés**

II. Déplacement de plusieurs individus

a.3. Plus forte discrétisation

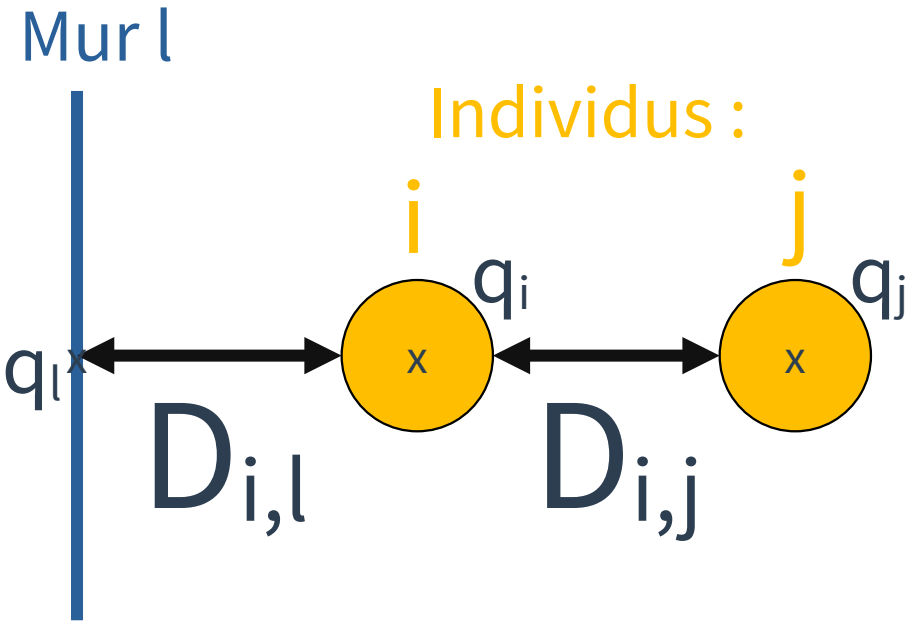




$O(n^4 \log(n))$

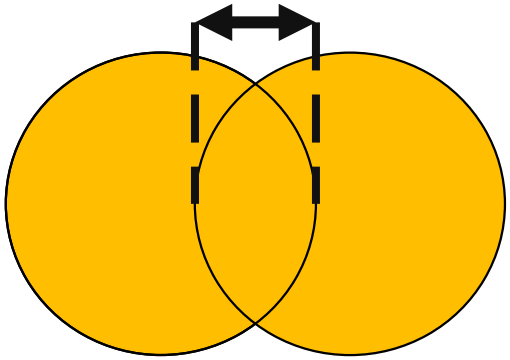
II. Déplacement de plusieurs individus

b. Utilisation d'Uzawa



Chevauchement maximum :

$\varepsilon = 0.1*r$

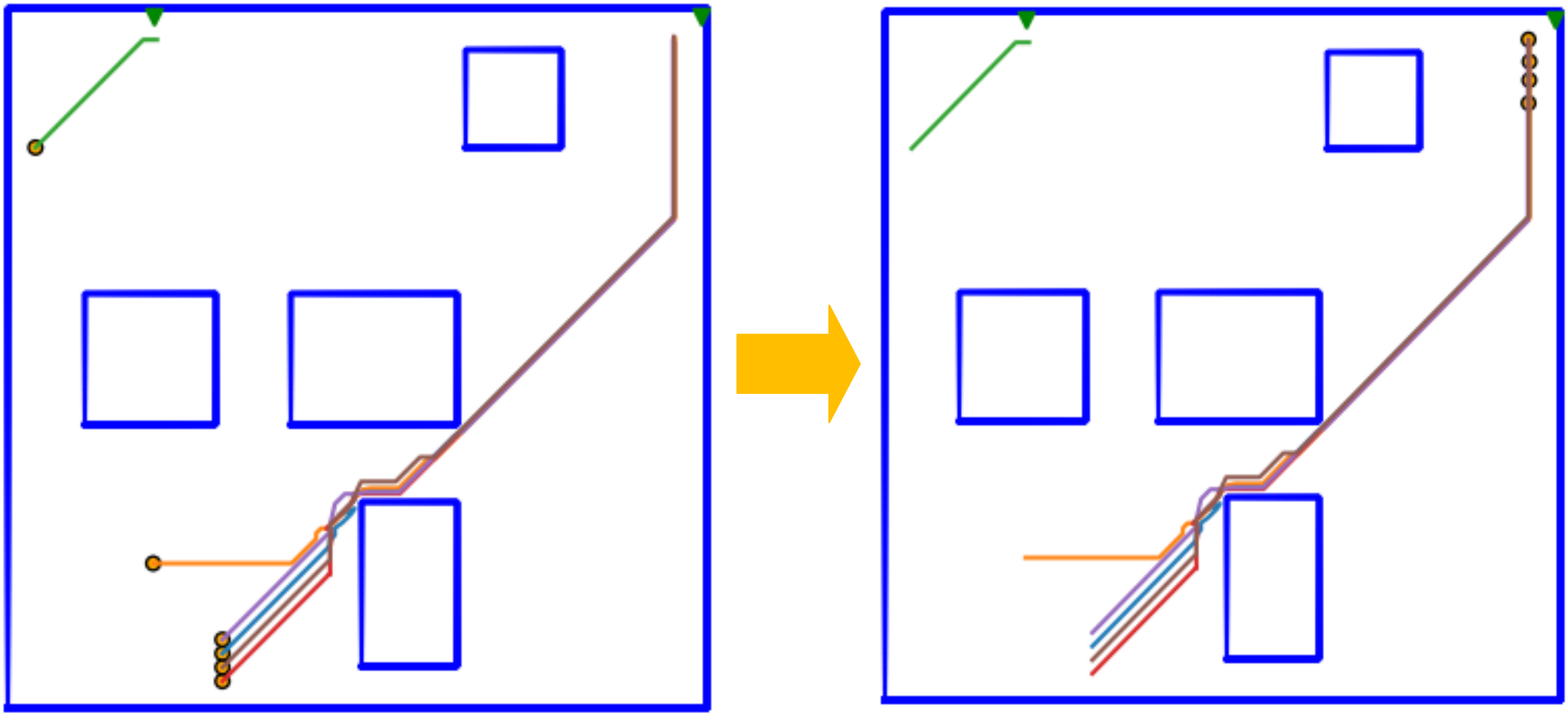


$$D_{i,j} = |q_i - q_j| - 2*r$$

$$D_{i,l} = |q_i - q_l| - r$$

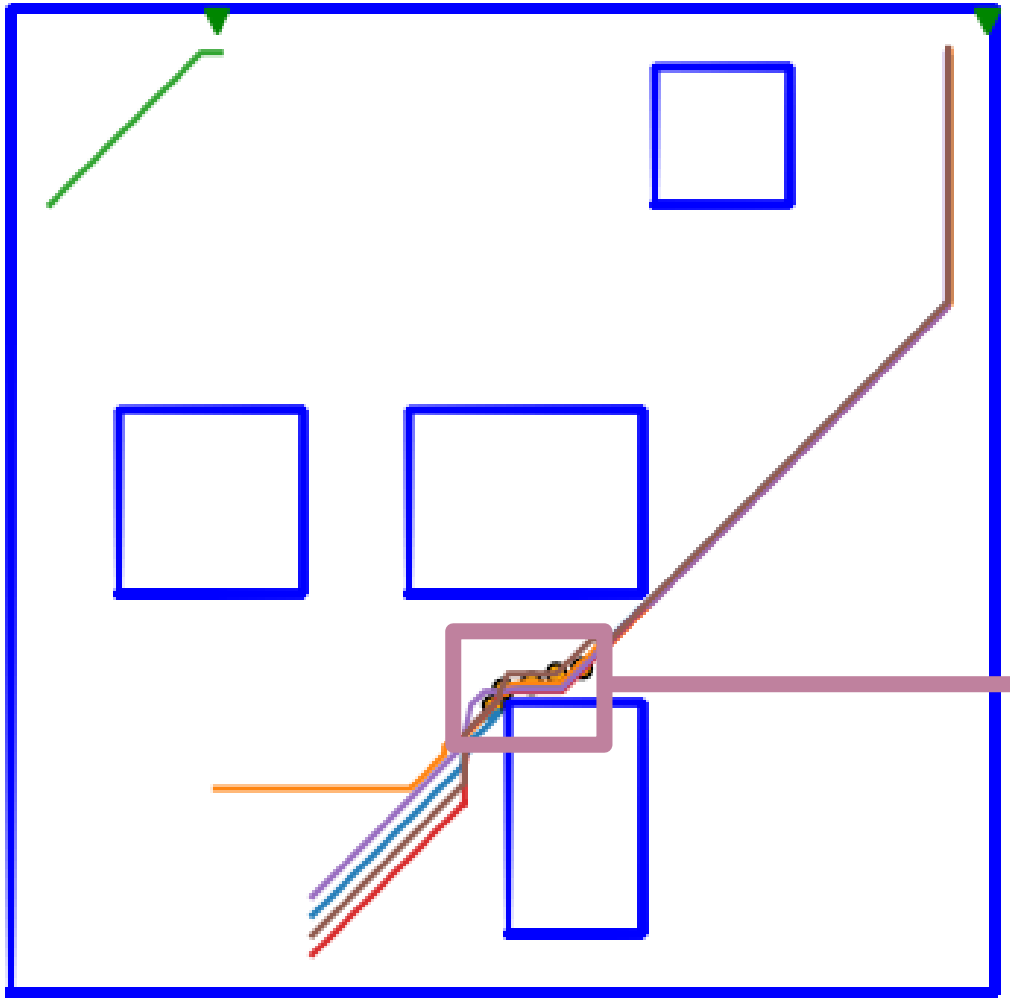
II. Déplacement de plusieurs individus

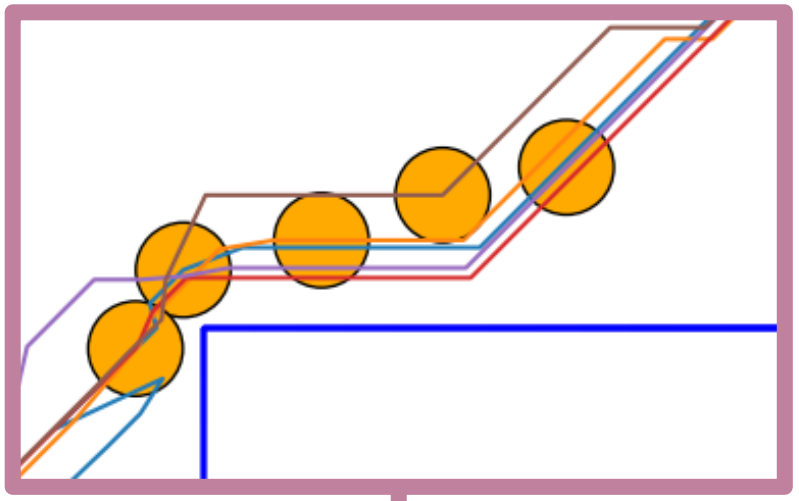
b. Utilisation d'Uzawa



II. Déplacement de plusieurs individus

b. Utilisation d'Uzawa



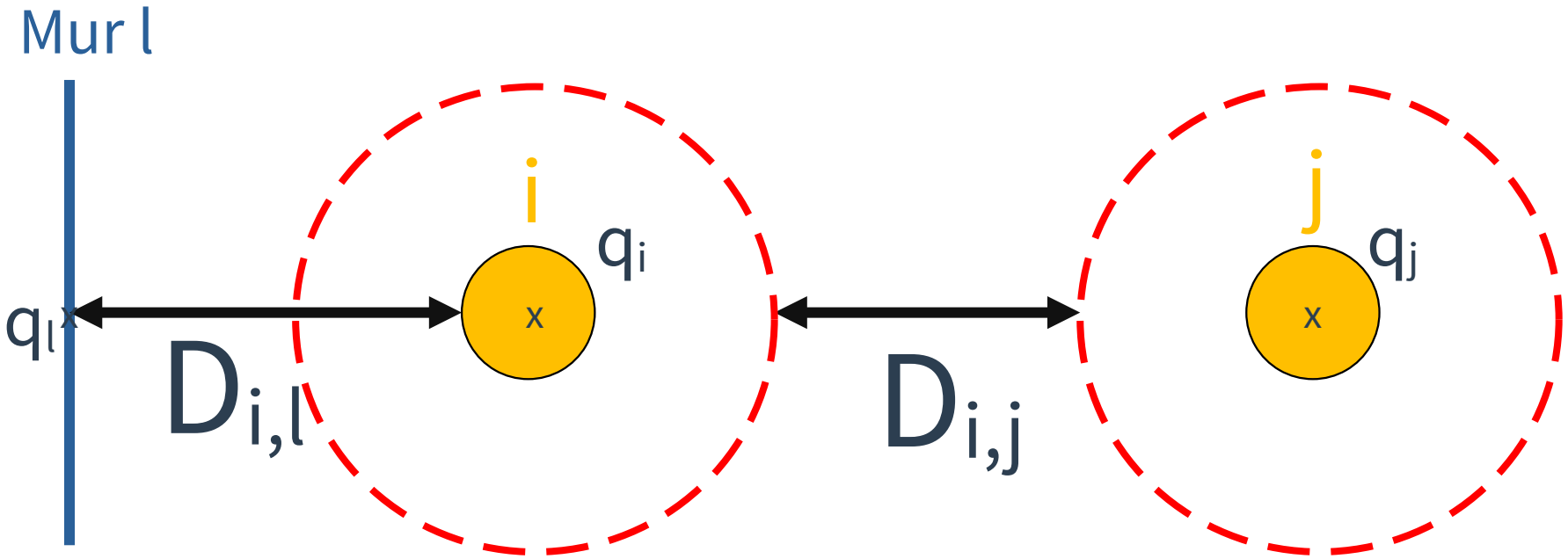


+

Pas de chevauchement

III. Prise en compte de la distanciation sociale

a. Nouveau calcul des distances



$$D_{i,j} = |q_i - q_j| - 2*R$$

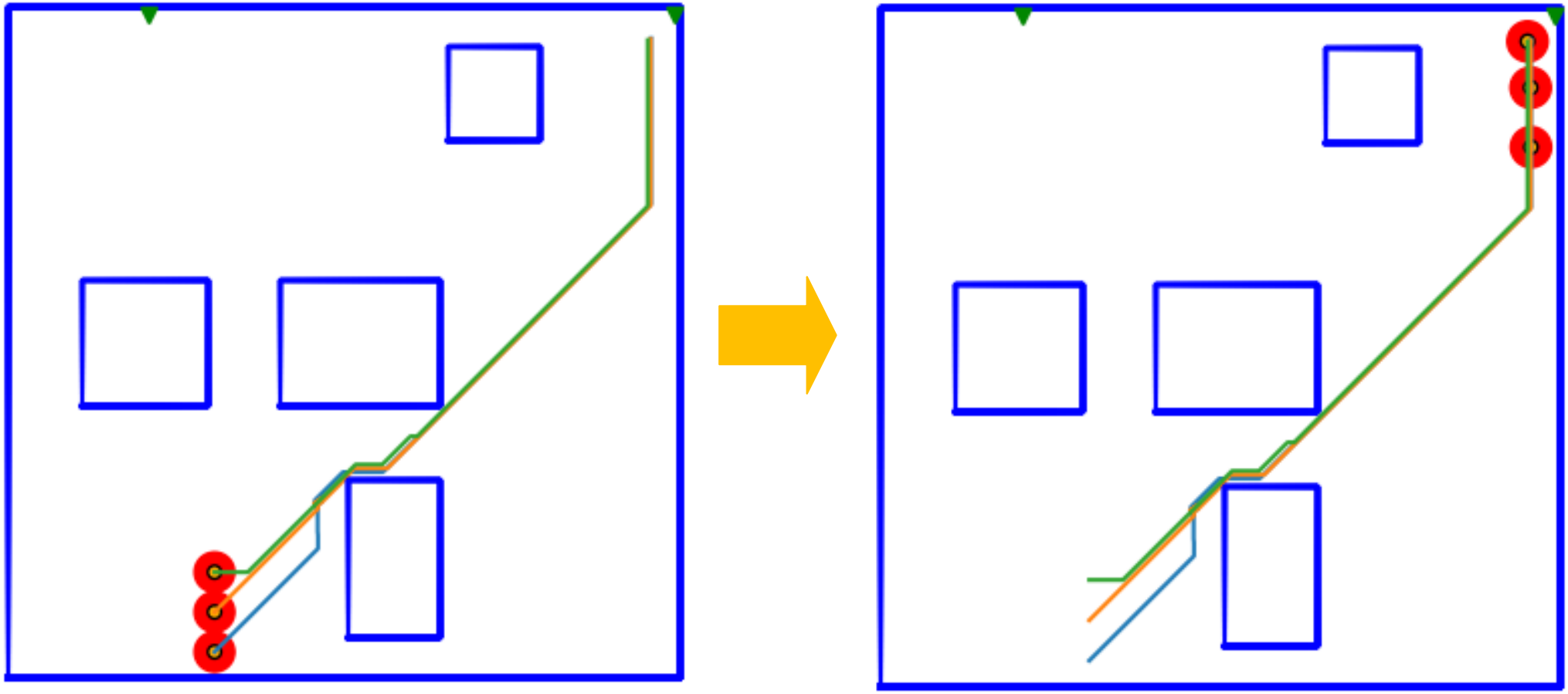
$$D_{i,l} = |q_i - q_l| - r$$

$$\varepsilon\_individus = 0.5*R$$

$$\varepsilon\_murs = 0.1*r$$

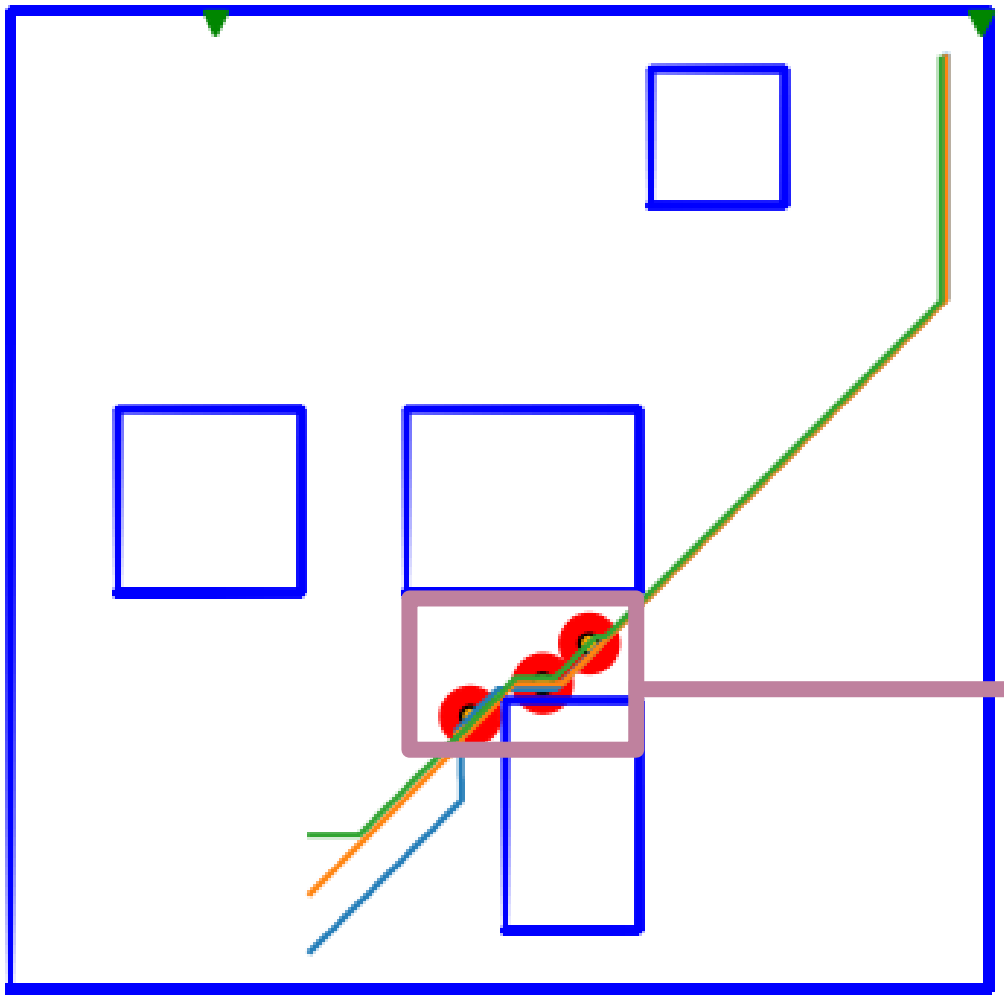
III. Prise en compte de la distanciation sociale

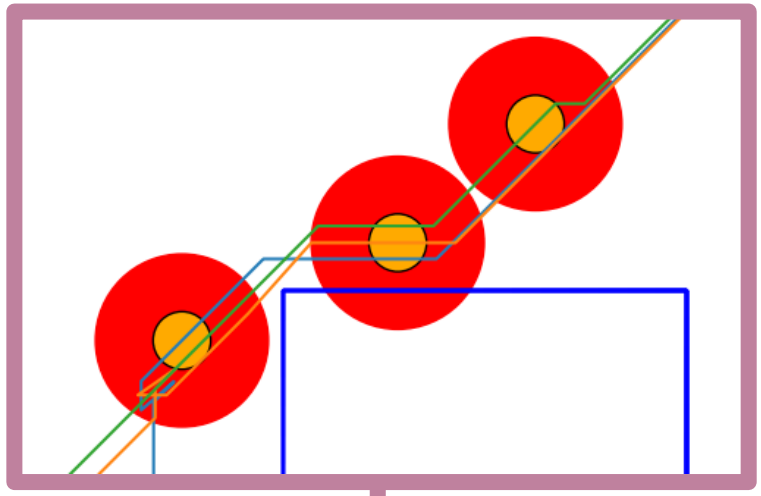
b. Nouvelle utilisation d'Uzawa



III. Prise en compte de la distanciation sociale

b. Nouvelle utilisation d'Uzawa





Respect des distances sanitaires

Bilan

- Caractère humain : réflexion et adaptation ;
- Différences entre les individus : taille et vitesse ;
- Petite surface de simulation ;
- Manque de données concrètes.

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ANNEXE

```
def topologie_mur(M,B):
    if 1 < M[0] < 1.2  and  0.5 < M[1] < 1.5:
        return np.inf
    else:
        return distance(M,B)

def search_pente(M,B,topologie,h):#M:coordonnées de départ, h:taille du pas,
topologie:focntion donnant le potentiel
    x ,y = M[0], M[1]
    cercle = np.linspace(0,2*np.pi,100)
    pente = topologie(M,B)
    N = M
    for theta in cercle:
        if pente >= topologie([x+h*np.cos(theta),y+h*np.sin(theta)],B):
            pente = topologie([x+h * np.cos(theta),y+ h * np.sin(theta)],B)
            N = [x+h * np.cos(theta),y+h * np.sin(theta)]
    return N# N:coordonnées du nouveau point

def recherche_chemin(A,B,topologie,N):# A point de départ et B d'arrivée
    Ms = [A]#    liste des coordonnées parcourues
    compteur =0
    while True and compteur < N:
        compteur += 1
        pente = search_pente(Ms[-1],B,topologie,0.02)
        Ms.append(pente)
        if len(Ms) > 2:
            if N == Ms[-3]:
                break
    return Ms
```

```
importance_potent = 0.75
importance_deplacement = 0.25/(2**(1/2))

dim = int
repulsifs = {'inv':set(coordonneés), 'plateau':set(coordonnées)}
murs = set(coordonnées)

def potent(pt,repulsifs,murs):
    if pt in murs:
        return np.inf
    V = 0
    for r in repulsifs['inv']:
        V += 1/(1+distance(r,pt))
    if pt in repulsifs['plateau']:
        V += 1
    return V

def calcul_poids(dim,repulsifs,murs):
    poids = [[[[importance_potent*potent((i+l-1,j+c-1),repulsifs,murs) +
importance_deplacement*distance((i,j),(i+l-1,j+c-1)) for c in range(3)] for l in range(3)]
for j in range(dim)] for i in range(dim)]
    return poids
```

```python
def dijkstra(dim,depart,arrivees,poids):#"arrivees" est un ENSEMBLE de points
    poids_tot = [[np.inf for j in range(dim+1)] for i in range(dim+1)]# dim+1 pour inclure
les contours de l'expérience et ne pas avoir un index out of range dans le while
    chemins = [[None for j in range(dim)] for i in range(dim)]

    poids_tot[depart[0]][depart[1]] = 0
    pt = depart
    poids_atteint = 0
    chemin = [pt]
    pts_passes = {pt}

    while pt not in arrivees:
        x,y = pt[0]-1, pt[1]-1
        for l in range(3):
            for c in range(3):
                if poids_tot[x+l][y+c] >  poids_atteint + poids[x+1][y+1][l][c]:
                    poids_tot[x+l][y+c] = poids_atteint + poids[x+1][y+1][l][c]
                    chemins[x+l][y+c] = chemin + [(x+l,y+c)]
        poids_min = np.inf
        pt_min = None
        for i in range(dim):
            for j in range(dim):
                if (i,j) not in pts_passes:
                    if poids_tot[i][j] < poids_min:
                        poids_min = poids_tot[i][j]
                        pt_min = (i,j)
        pt = pt_min
        pts_passes.add(pt)
        poids_atteint = poids_min
        chemin = chemins[pt[0]][pt[1]]

    return chemin
```

```python
def directions_souhaitees(dim,arrivees,repulsifs,murs):
    poids = calcul_poids(dim,repulsifs,murs)
    directions = [[(i,j) for j in range(dim)] for i in range(dim)]
    points_fleches = arrivees.copy()
    classement = classement_distance(dim,arrivees,murs)
    for depart in classement:
        if depart not in points_fleches:
            chemin = dijkstra(dim,depart,arrivees,poids)
            for i in range(len(chemin)-1):
                if chemin[i] in points_fleches:
                    break
                else:
                    points_fleches.add(chemin[i])

                    print(len(points_fleches))

                    directions[chemin[i][0]][chemin[i][1]] = (chemin[i+1][0],chemin[i+1][1])
    return directions

def classement_distance(dim,arrivees,murs):
    map = []
    for i in range(dim):
        for j in range(dim):
            if (i,j) not in murs:
                map.append((i,j))
    map = tri_fusion(map,arrivees)
    return map
```

```
def vitesse_souhaitee(dim,position,directions):
    if position == None:
        return (0,0)
    coeff = int(dim/len(directions))
    x,y = position
    i = int(x//coeff)
    j = int(y//coeff)
    dx = directions[i][j][0] - i
    dy = directions[i][j][1] - j
    d = ((dx**2)+(dy**2))**(1/2)
    if d == 0:
        return (0,0)
    return (dx/d,dy/d)

def vitesses_souhaitees(dim,positions,directions):
    vitesses = []
    for i in range(len(positions)):
        vitesses.append([vitesse_souhaitee(dim,positions[i],directions)
[0],vitesse_souhaitee(dim,positions[i],directions)[1]])
    return vitesses
```

```
r = 1
h = 1
```

```
def uzawa_initialisation(positions,listes_murs):
    global r

    n = len(positions)
    n_obst = len(listes_murs)

    D = []
    E = []
    for q1 in range(n):
        D.append([])
        E.append([])

        for q2 in range(n):
            d = distance(positions[q1],positions[q2])
            D[q1].append(d - 2*r)
            if d != 0:
                E[q1].append(((positions[q2][0] - positions[q1][0])/d , (positions[q2][1] - positions[q1][1])/d ))
            else:
                E[q1].append((0,0))

        for obst in range(n_obst):
            pt_proche = (np.inf,np.inf)
            d = distance(positions[q1],pt_proche)
            for mur in listes_murs[obst]:
                if distance(positions[q1],mur) < d:
                    pt_proche = mur
                    d = distance(positions[q1],pt_proche)
            D[q1].append(d-r)
            if d !=0:
                E[q1].append( ((pt_proche[0]-positions[q1][0])/d, (pt_proche[1]-positions[q1][1])/d ) )
            else:
                E[q1].append( (0, 0) )

    epsilon = 0.1*r
    iter_max = 5000
    rho = 1# constante sélectionnée après l'essai de plusieurs valeurs

    return D,E,n,n_obst,epsilon,iter_max,rho
```

```python
def phi(v,E,n,n_obst):
    global h

    retour = []
    for i in range(n):
        retour.append([])
        for nul in range(i+1):
            retour[i].append(0)
        for j in range(i+1,n):
            G = [[0,0] for _ in range(i)] + [[-1*E[i][j][0], -1*E[i][j][1]]] + [[0,0] for _ in
range(i+1,j)] + [[E[i][j][0],E[i][j][1]]] + [[0,0] for _ in range(j+1,n)]
            retour[i].append(dot(np.array(G),v))# dot correspond au produit scalaire canonique
        for l in range(n_obst):
            G = [[0,0] for _ in range(i)] + [[-1*E[i][n+l][0], -1*E[i][n+l][1]]] + [[0,0] for _ in
range(i+1,n)]
            retour[i].append(dot(np.array(G),v))
    return -1*h*np.array(retour)
def phi_star(v,E,n,n_obst):
    global h
    retour = np.array([[0.,0.] for i in range(n)])
    for i in range(n):
        for j in range(i+1,n):
            G = [[0,0] for _ in range(i)] + [[-1*E[i][j][0], -1*E[i][j][1]]] + [[0,0] for _ in
range(i+1,j)] + [[E[i][j][0],E[i][j][1]]] + [[0,0] for _ in range(j+1,n)]
            retour -=  v[i,j] * np.array(G)
        for l in range(n_obst):
            G = [[0,0] for _ in range(i)] + [[-1*E[i][n+l][0], -1*E[i][n+l][1]]] + [[0,0] for _ in
range(i+1,n)]
            retour -= v[i,n+l] * np.array(G)
    return h*retour
```

```
def projete(mu):
    mu_retour = mu.copy()
    for i in range(len(mu_retour)):
        for j in range(len(mu_retour[0])):
            if mu_retour[i,j] < 0:
                mu_retour[i,j] = 0
    return mu_retour

def uzawa(positions,u,D,E,n,n_obst,epsilon,iter_max,rho,listes_murs):
    global r
    global h

    positions_candidat = positions + h*u

    v = u.copy()
    k = 0

    liste_distances = [distance(tuple(positions_candidat[i]),tuple(positions_candidat[j])) -2*r for i in range(n) for j in
range(i+1,n)]
    for i in range(n):
        for l in range(n_obst):
            liste_distances.append(min([distance(tuple(positions_candidat[i]), mur)-r for mur in listes_murs[l]]))
    Dmin = min(liste_distances)
    mu = np.array([[0 for j in range(n+n_obst)] for i in range(n)])

    while (k<iter_max) and (Dmin<-1*epsilon):
        v = u - phi_star(mu,E,n,n_obst)
        mu = projete(mu+rho*(phi(v,E,n,n_obst) - np.array(D)))

        positions_candidat = positions + h*v

        liste_distances = [distance(tuple(positions_candidat[i]),tuple(positions_candidat[j])) -2*r for i in range(n) for j
in range(i+1,n)]
        for i in range(n):
            for l in range(n_obst):
                liste_distances.append(min([distance(tuple(positions_candidat[i]), mur)-r for mur in listes_murs[l]]))
        Dmin = min(liste_distances)
        k += 1

    print(Dmin)
```

```
departs = set(coordonnées)
listes_murs = list[list[coordonnées]]


def mouvement_foule(dim,departs,listes_murs,directions):
    etapes_max = 1000
    nbr_individus = len(departs)
    positions = []
    etapes = []
    mouvement_fini = []
    for depart in departs:
        positions.append(depart)
    etapes.append(positions)
    vitesses_souhaitees_brutes = vitesses_souhaitees(dim,positions,directions)
    for i in range(len(positions)):
        if vitesses_souhaitees_brutes[i] == [0,0]:
            mouvement_fini.append(True)
        else:
            mouvement_fini.append(False)

    while False in mouvement_fini and len(etapes)< etapes_max:
```

...Page suivante ⟶

```
    while False in mouvement_fini and len(etapes)< etapes_max:
        positions_nettoyees = []
        vitesses_souhaitees_nettes = []
        vitesses_souhaitees_brutes = vitesses_souhaitees(dim,positions,directions)
        for i in range(len(vitesses_souhaitees_brutes)):
            if vitesses_souhaitees_brutes[i] == [0,0]:
                mouvement_fini[i] = True
            else:
                positions_nettoyees.append(list(positions[i]))
                vitesses_souhaitees_nettes.append(vitesses_souhaitees_brutes[i])
        if len(positions_nettoyees)==0:
            break

        D,E,n,n_obst,epsilon,iter_max,rho = uzawa_initialisation(positions_nettoyees,listes_murs)
        vitesses_souhaitees_nettes = np.array(vitesses_souhaitees_nettes)
        positions_nettoyees = np.array(positions_nettoyees)

        nouvelles_positions =
uzawa(positions_nettoyees,vitesses_souhaitees_nettes,D,E,n,n_obst,epsilon,iter_max,rho,listes_murs)

        positions = []
        j = 0
        for i in range(nbr_individus):
            if mouvement_fini[i] == True:
                positions.append(None)
            else:
                positions.append(tuple(nouvelles_positions[j]))
                j += 1

        etapes.append(positions)

    return etapes
```

```
r = 1
R = 3
h = 1
def uzawa_initialisation_sanitaire(positions,listes_murs):
    global r
    global R

    n = len(positions)
    n_obst = len(listes_murs)

    D = []
    E = []
    for q1 in range(n):
        D.append([])
        E.append([])

        for q2 in range(n):
            d = distance(positions[q1],positions[q2])
            D[q1].append(d - 2*R)
```

[...]

```
        for obst in range(n_obst):
            pt_proche = (np.inf,np.inf)
            d = distance(positions[q1],pt_proche)
            for mur in listes_murs[obst]:
                if distance(positions[q1],mur) < d:
                    pt_proche = mur
                    d = distance(positions[q1],pt_proche)
            D[q1].append(d-r)
```

[...]

```
epsilon_murs = 0.1*r
epsilon_sanitaire = 0.5*R
iter_max = 5000
rho = 1

return D,E,n,n_obst,epsilon_sanitaire,epsilon_murs,iter_max,rho
```

```
def
uzawa_sanitaire(positions,u,D,E,n,n_obst,epsilon_sanitaire,epsilon_murs,iter_max,rho,listes_murs):
    global r
    global R
    global h

    positions_candidat = positions + h*u

    v = u.copy()
    k = 0

    liste_distances_sanitaire = [distance(tuple(positions_candidat[i]),tuple(positions_candidat[j]))
-2*R for i in range(n) for j in range(i+1,n)]
    if len(liste_distances_sanitaire) >= 1:
        Dmin_sanitaire = min(liste_distances_sanitaire)
    else:
        Dmin_sanitaire = np.inf

    liste_distances_murs = []
    for i in range(n):
        for l in range(n_obst):
            liste_distances_murs.append(min([distance(tuple(positions_candidat[i]), mur)-r for mur in
listes_murs[l]]))
    Dmin_murs = min(liste_distances_murs)
```

[...]