Simflow

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1. 概述

一套简易的机械臂仿真工作流测试框架。

安装

包：`pip3 install pysimflow`

源代码：

示例工作流

获取一堆工件的深度图：`python3 test.py`

获取一堆工件的姿态数据：`python3 test0.py`

混合拆垛演示：`python3 test1.py`

无序抓取演示：`python3 test2.py`

虚拟相机拍摄点云：`python3 test3.py`

标定：`python3 test5.py`

2. 工作计划

目标	任务	问题	备注
前端接口实现	场景查看	载入/重置	
		获取物体标识	
		获取场景画面	
		暂停/继续仿真	
		平移/旋转/缩放/焦点	
		视图切换-前后左右	
		绘制原点/碰撞点	
		关闭场景	
	场景编辑	基础模型	
		坐标检测	
		选择/添加/删除/保存	
		透明化	
		移动/旋转/缩放	
	物体	位置/姿态	
		标识	
		模型更换	
		纹理更换	
	物体.机械臂	获取/设置末端执行器	
		获取/设置末端执行器-位置/姿态	
		设置末端执行器-数字输出	
		获取/设置关节位置	
		获取/设置速度	
		设置/前往休息点	
	物体.相机	获取相机画面	
		获取/设置内参外参	

目标	任务	问题	备注
		设置/清除点云	
	物体.码垛器	区域参数	
		工件更换	
	物体.放置器	区域参数	
		获取/设置工件	
		获取/设置工件纹理	
		获取/设置放置点	
		获取/设置总计工件数	
		获取/设置缩放因子	
		获取/设置放置模式	
	工作流	获取可用节点	
		设置/获取	
		启动/停止	

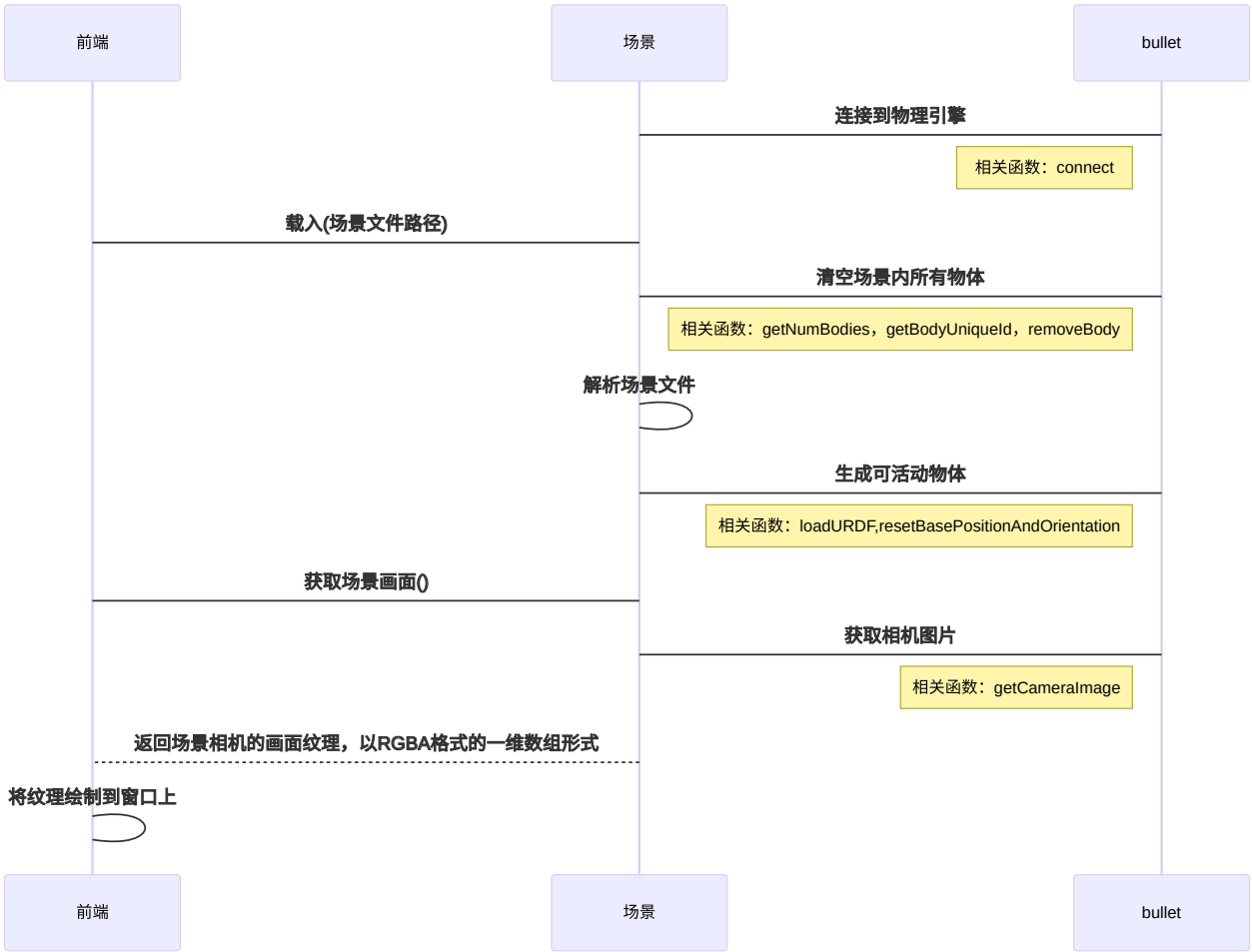
3. 功能接口

场景-载入场景并获取画面

通过解析一个场景文件并加载其定义的物体到分拣场景中，通过渲染到纹理技术获取场景画面到前端显示。

文件定义如下：

```
scene_profile = {
  "active_objects": [
    {
      "kind":"Robot",
      "name":"robot",
      "base":"./data/robots/ur5.urdf",
      "pos":[0,0,0],
      "rot":[0,0,1.57],
      "end_effector":"./data/end_effectors/magnet.urdf"
    },
    {
      "kind":"Placer",
      "name":"placer",
      "base":"./data/objects/tray/traybox.urdf",
      "pos":[0,-0.5,0.001],
      "rot":[0,0,0],
      "center":[0.0,-0.5,0.25],
      "interval":0.1,
      "amount":30,
      "workpiece":"./data/workpieces/lego/lego.urdf"
    },
    {
      "kind":"Camera3D",
      "name":"camera",
      "base":"./data/cameras/camera3d.urdf",
      "pos":[-0.5,-0.5,0.0],
      "rot":[0.0,0.0,-1.57],
      "fov": 45,
      "forcal": 0.01,
      "image_size": [300,300],
      "image_path":"./guagua.png"
    }
  ],

  "workflow": {...} # 工作流
}
```


前端
场景
bullet
连接到物理引擎
相关函数：connect
载入(场景文件路径)
清空场景内所有物体
相关函数：getNumBodies，getBodyUniqueId，removeBody
解析场景文件
生成可活动物体
相关函数：loadURDF,resetBasePositionAndOrientation
获取场景画面()
获取相机图片
相关函数：getCameraImage
返回场景相机的画面纹理，以RGBA格式的一维数组形式
将纹理绘制到窗口上
前端
场景
bullet

Python

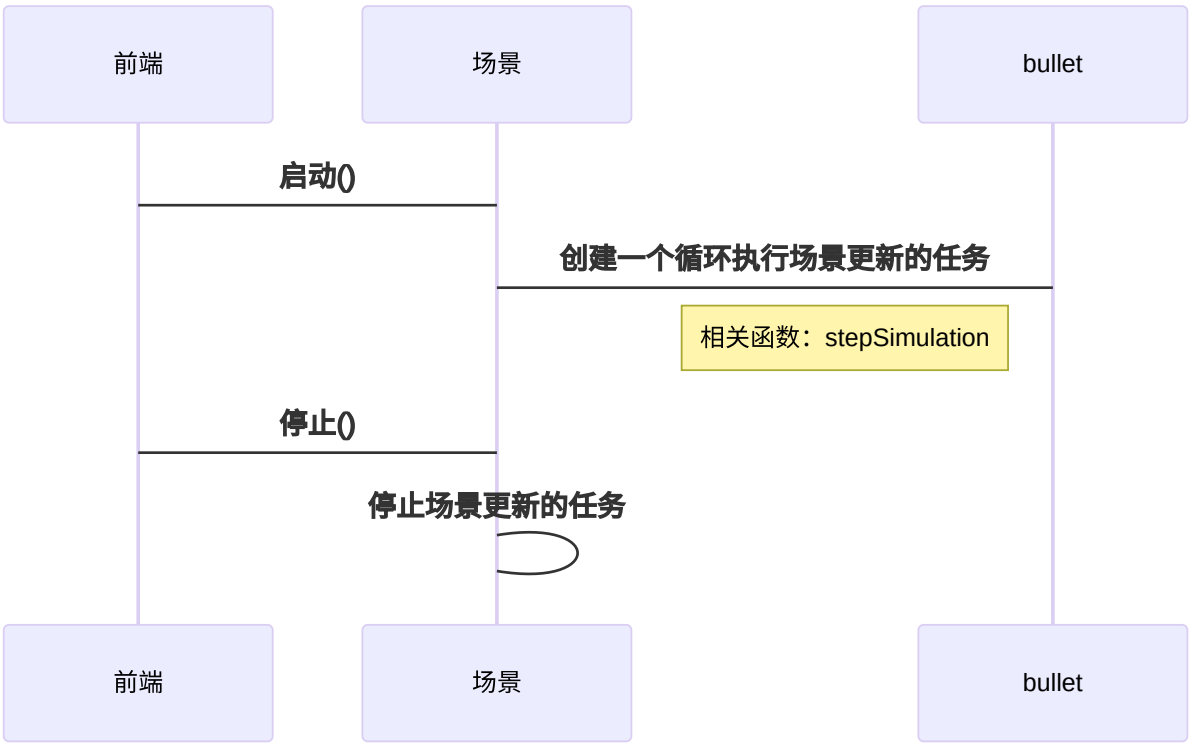
```python
import os
from digitaltwin import Scene
import digitaltwin_data

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
scene.load(os.path.join(data_dir,'scenes/空.json'))

rgba = scene.rtt()
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
  auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
  scene->load("./digitaltwin_data/scenes/空.json");

  Texture texture;
  scene->rtt(texture);
  return 0;
}
```

场景-启动/停止

当场景布置完毕后，执行启动即可持续进行物理运算。停止则暂停物理运算。


前端
场景
bullet
启动()
创建一个循环执行场景更新的任务
相关函数：stepSimulation
停止()
停止场景更新的任务
前端
场景
bullet

Python

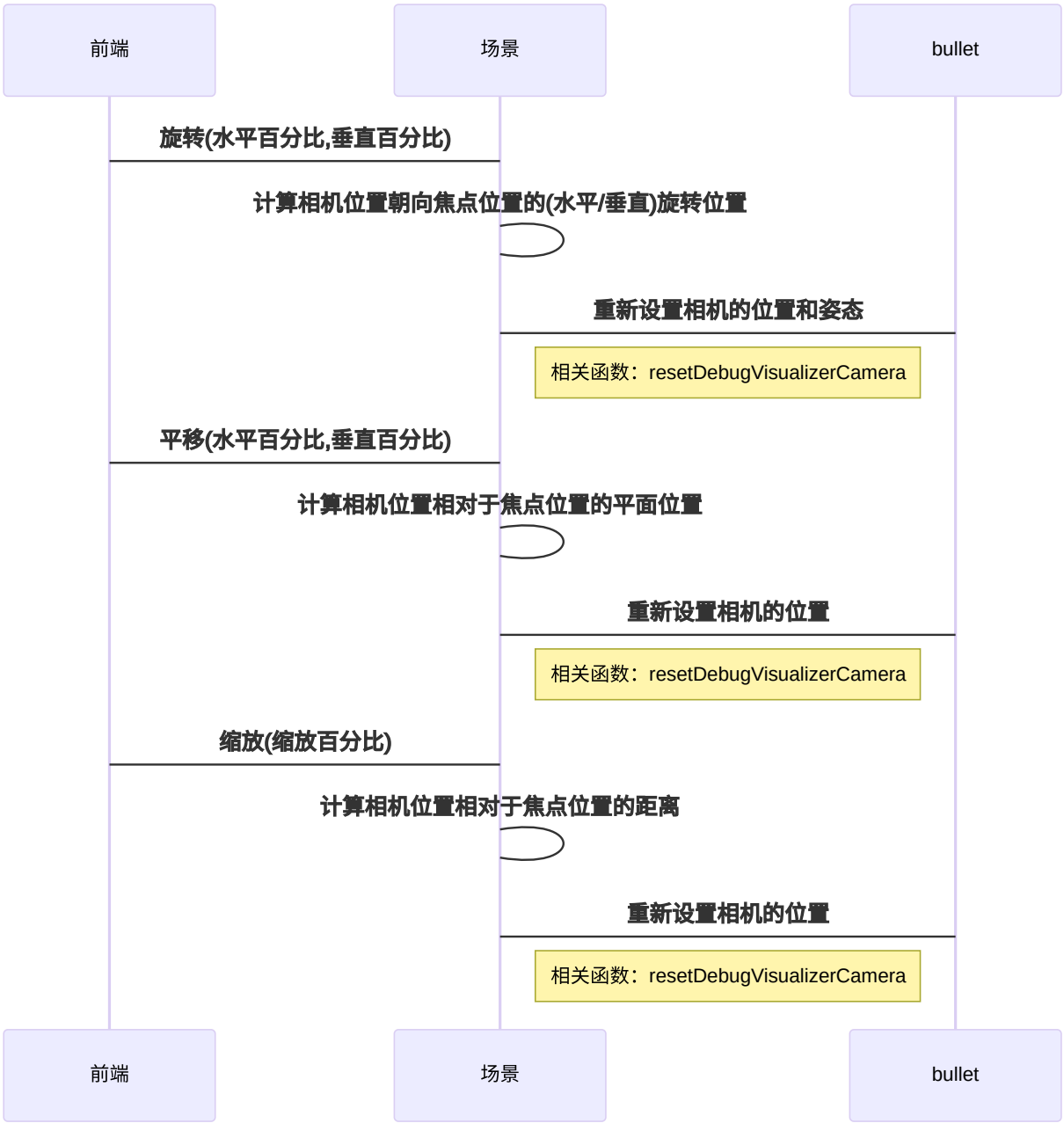
```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/混合拆垛.json'))

stacker = scene.active_objs_by_name['stacker']
stacker.generate()

playing = True
def updating():
  while playing:
    scene.update_for_tick(1/180.)
    time.sleep(1/180.)

t = Thread(target=updating)
t.start()

time.sleep(1)

playing = False
time.sleep(1)

playing = True
t = Thread(target=updating)
t.start()
```

C++

```
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
  auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
  scene->load("./digitaltwin_data/scenes/混合拆垛.json");

  this_thread::sleep(chrono::seconds(1));
  scene->play(false);

  this_thread::sleep(chrono::seconds(2));

  scene->play();
  return 0;
}
```

场景-视口控制

用户会经常使用鼠标或者手势进行镜头控制。


前端
场景
bullet
旋转(水平百分比,垂直百分比)
计算相机位置朝向焦点位置的(水平/垂直)旋转位置
重新设置相机的位置和姿态
相关函数：resetDebugVisualizerCamera
平移(水平百分比,垂直百分比)
计算相机位置相对于焦点位置的平面位置
重新设置相机的位置
相关函数：resetDebugVisualizerCamera
缩放(缩放百分比)
计算相机位置相对于焦点位置的距离
重新设置相机的位置
相关函数：resetDebugVisualizerCamera
前端
场景
bullet

Python

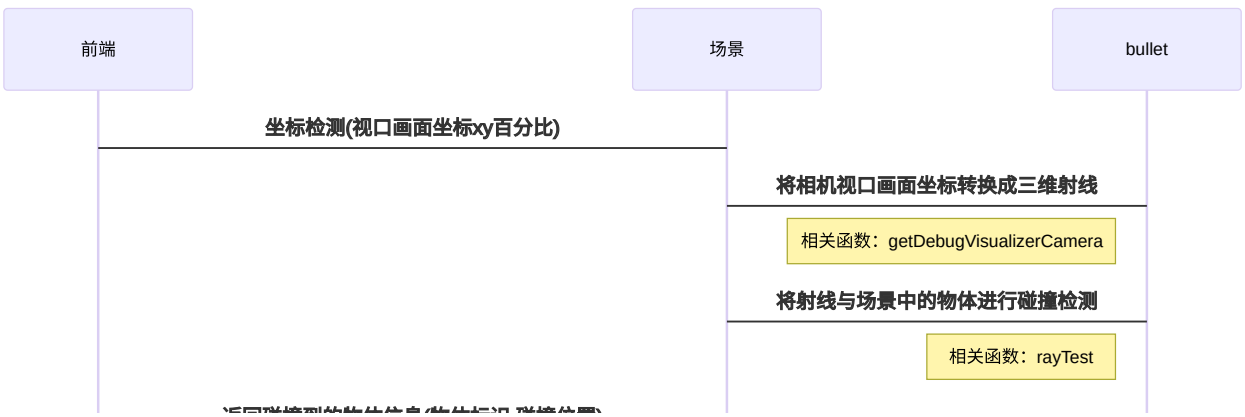
```
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
scene.load(os.path.join(data_dir,'scenes/空.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

while True:
    time.sleep(0.1)
    scene.rotate(0.001,0)
    time.sleep(0.1)
    scene.pan(0.001,0)
```

C++

```
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
  auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
  scene->load("./digitaltwin_data/scenes/空.json");

  while(true) {
    scene->rotate(0.001,0.0);
    this_thread::sleep_for(chrono::milliseconds(100));
    scene->pan(0.001,0.0);
    this_thread::sleep_for(chrono::milliseconds(100));
  }

  return 0;
}
```

场景-获取选中物体的信息

用户在布置场景的时候会通过鼠标获取物体的各种信息。




返回碰撞到的物体信息(物体标识,碰撞位置)
选择(物体标识)
获取物体属性
相关函数：getBasePositionAndOrientation
alt
[物体]
返回物体的属性信息(标识,类别,模型,位置,姿态,...额外的属性)
opt
[物体.机器人]
额外的属性(末端执行器)
opt
[物体.相机]
额外的属性(视口大小)
opt
[物体.码垛器]
额外的属性(区域大小,工件)
opt
[物体.堆叠器]
额外的属性(区域大小,工件)
显示物体属性
前端
场景
bullet

Python

```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/标定测试.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

obj = editor.ray(0.5,0.5)
print(obj)

robot = scene.active_objs_by_name[obj['name']]
print(robot.get_pos())
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    RayInfo hit;
    editor->ray(0.5,0.5,hit);

    auto objs = scene->get_active_objs();
    auto obj = objs[hit.name];

    auto pos = obj->get_pos();

    cout << pos[0] << endl
        << pos[1] <<endl
        << pos[2] << endl;

    return 0;
}
```

场景-保存

当对场景的物体进行修改之后，调用此函数来进行保存。

Python

```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/标定测试.json'))

def updating():
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

plane = scene.active_objs_by_name['plane']

plane.set_pos([0,0,1])
scene.save()
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto obj = objs['plane'];
    obj.set_pos({0,0,1});
    scene.save();
    return 0;
}
```

场景.编辑-基础模型

Python

```python
import time
from digitaltwin import Scene,Workflow,Editor
import os
from threading import Thread
import numpy as np
import digitaltwin_data

data_dir = digitaltwin_data.get_data_path()

scene = Scene(1024,768,data_dir)
editor = Editor(scene)

scene.load(os.path.join(data_dir,'scenes/空.json'))

def updating():
  while True:
    scene.update_for_tick(1/180.)
    time.sleep(1/180.)

t = Thread(target=updating)
t.start()

editor.add_cube([0,0,0],[0,0,0],[1,0.5,0.5])
editor.add_cylinder([1,0,0],[0,0,0],0.5,0.5)
editor.add_box([-1,0,0],[0,0,0],[1,1,0.5],0.1)
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/空.json");

    string name;
    editor->add_cube({0,0,0},{0,0,0},{1,0.5,0.5},name);
    editor->add_cylinder({1,0,0},{0,0,0},0.5,0.5,name);
    editor->add_box({-1,0,0},{0,0,0},{1,1,0.5},0.1,name);
    return 0;
}
```

场景.编辑-机械臂

Python

```python
from threading import Thread
import time
from digitaltwin import Scene,Editor

scene = Scene(1024, 768)
scene.load('./digitaltwin_data/scenes/空.json')
editor = Editor(scene)

def updating():
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

obj = editor.add('Robot','robots/gp12/gp12.urdf',[0,0,1],[0,0,0],[1,0,0])
scene.active_objs_by_name[obj['name']].set_end_effector('end_effectors/gripper_gp12/gripper_gp12
.urdf')
```

C++

```
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/空.json");

    string name;
    editor->add("Robot",'robots/gp12/gp12.urdf',{0,0,1},{0,0,0},{1,0,0},name);

    auto objs = scene->get_active_objs();
    dynamic_cast<Robot*>(objs[name])-
>set_end_effector("end_effectors/gripper_gp12/gripper_gp12.urdf");
    return 0;
}
```

场景.编辑-删除

Python

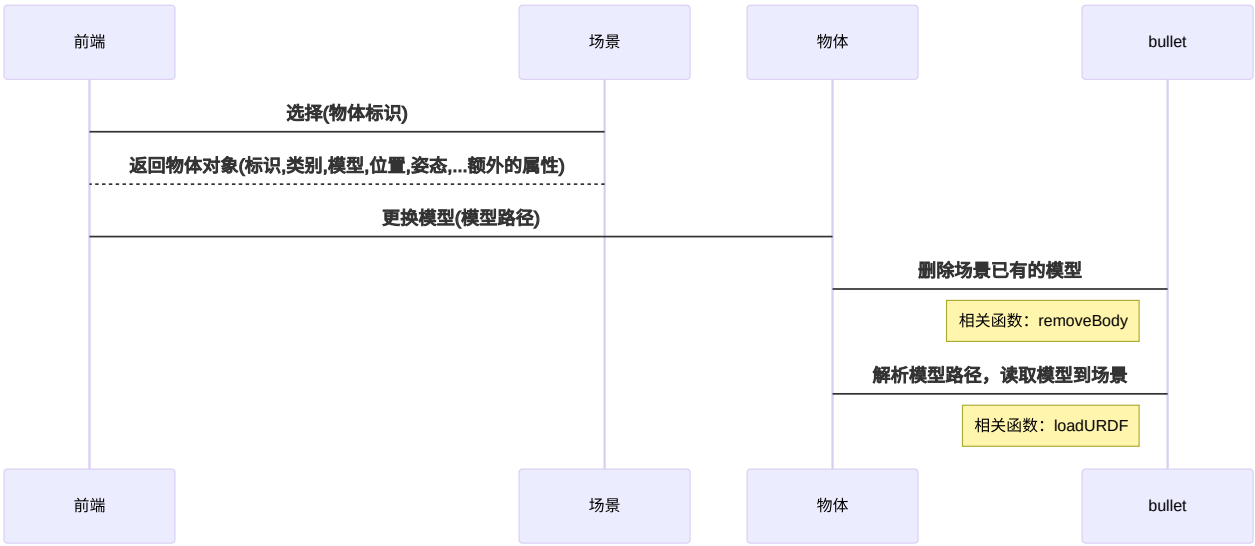
```python
from threading import Thread
import time
from digitaltwin import Scene,Editor

scene = Scene(1024, 768)
scene.load('./digitaltwin_data/scenes/空.json')
editor = Editor(scene)


def updating():
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

obj = editor.add('Robot','robots/gp12/gp12.urdf',[0,0,1],[0,0,0],[1,0,0])
editor.remove(obj['name'])
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/空.json");

    string name;
    editor->add("Robot",'robots/gp12/gp12.urdf',{0,0,1},{0,0,0},{1,0,0},name);
    editor->remove(name);
    return 0;
}
```

物体-更换模型

用户布置场景的时候会对模型进行替换。



Python

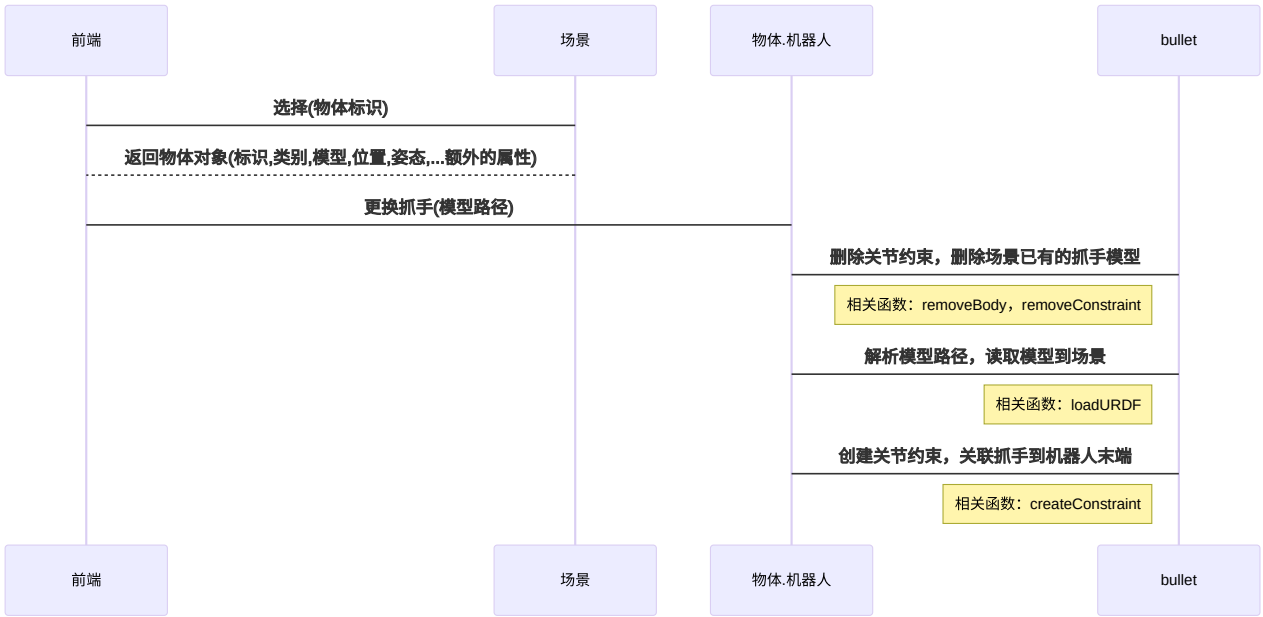
```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/标定测试.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

plane = scene.active_objs_by_name['plane']
plane.set_base('containers/tray/tray.urdf')
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto plane = objs["plane"];
    plane->set_base("containers/tray/tray.urdf");
    return 0;
}
```

物体.机械臂-末端执行器

用户为不同工件采用不同的机器人抓手。



Python

```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/标定测试.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

robot = scene.active_objs_by_name['robot']
robot.set_end_effector('end_effectors/gripper_ur5/gripper_ur5.urdf')
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto robot = dynamic_cast<Robot*>(objs["robot"]);
    robot->set_end_effector("end_effectors/gripper_ur5/gripper_ur5.urdf");
    return 0;
}
```

物体.机械臂-末端执行器-位姿

Python

```python
from threading import Thread
from digitaltwin import Scene
import digitaltwin_data
import os

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
scene.load(os.path.join(data_dir,'scenes/标定测试.json'))

def updating():
  import time
  while True:
    scene.update_for_tick(1/180.)
    time.sleep(1/180.)

t = Thread(target=updating)
t.start()

robot = scene.active_objs_by_name['robot']
robot.set_end_effector_pose([0,-0.5,0.1,0.785,0,0])
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto robot = dynamic_cast<Robot*>(objs["robot"]);
    robot->set_end_effector_pos({0,-0.5,0.1});
    robot->set_end_effector_rot({0.785,0,0});
    return 0;
}
```

物体.机械臂-末端执行器-数字输出

Python

```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time


data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/无序抓取-真实.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

robot = scene.active_objs_by_name['robot']

time.sleep(2)
robot.end_effector_obj.do(True)
time.sleep(2)
robot.end_effector_obj.do(False)
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto robot = dynamic_cast<Robot*>(objs["robot"]);
    this_thread::sleep_for(chrono::seconds(1));
    robot->digital_output(true);
    this_thread::sleep_for(chrono::seconds(1));
    robot->digital_output(false);
    return 0;
}
```

物体.机械臂-关节控制

Python

```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time


data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/标定测试.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

robot = scene.active_objs_by_name['robot']

route_joint_positions = [
    [0.0,0,0,0,0,0,0.0],
    [0.1,0,0,0,0,0,0.1],
    [0.2,0,0,0,0,0,0.2],
    [0.3,0,0,0,0,0,0.3],
    [0.4,0,0,0,0,0,0.4],
    [0.5,0,0,0,0,0,0.5],
    [0.6,0,0,0,0,0,0.6]
]

for joint_pos_list in route_joint_positions:
    robot.set_joints(joint_pos_list)
    time.sleep(0.5)
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto robot = dynamic_cast<Robot*>(objs["robot"]);

    list<vector<float>> route_joint_positions = {
        {0.0,0,0,0,0,0,0.0},
        {.1,0,0,0,0,0,0.1},
        {0.2,0,0,0,0,0,0.2},
        {0.3,0,0,0,0,0,0.3},
        {0.4,0,0,0,0,0,0.4},
        {0.5,0,0,0,0,0,0.5},
        {0.6,0,0,0,0,0,0.6}
    };

    for(auto joint_pos_list : route_joint_positions) {
        robot->set_joints(joint_pos_list);
        this_thread::sleep_for(chrono::seconds(1));
    }

    return 0;
}
```

物体.机械臂-速度控制

Python

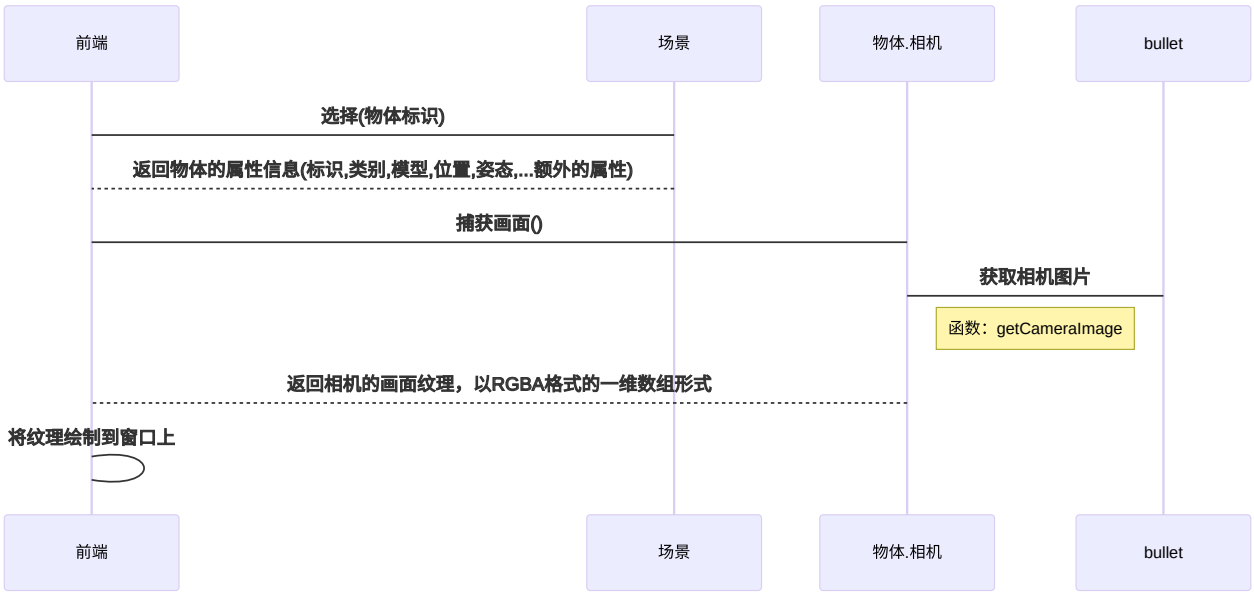
```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/标定测试.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

robot = scene.active_objs_by_name['robot']
robot.signal_move(
    mode='joint',
    speed=0.1,
    point=[0,-0.5,0.1,0.785,0,0])
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto robot = dynamic_cast<Robot*>(objs["robot"]);

    robot->signal("move","mode='joint',speed=0.1,point=[0,-0.5,0.1,0.785,0,0]");

    return 0;
}
```

物体.相机-捕获画面

虚拟相机的拍照功能。


前端
场景
物体.相机
bullet
选择(物体标识)
返回物体的属性信息(标识,类别,模型,位置,姿态,...额外的属性)
捕获画面()
获取相机图片
函数：getCameraImage
返回相机的画面纹理，以RGBA格式的一维数组形式
将纹理绘制到窗口上
前端
场景
物体.相机
bullet

Python

```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/标定测试.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

camera = scene.active_objs_by_name['camera']

rgba,depth = camera.rtt()
print(len(rgba),len(depth))
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto camera = dynamic_cast<Camera3D*>(objs["camera"]);

    Texture texture;
    camera->rtt(texture);

    return 0;
}
```

物体.相机-设置/清除点云

Python

```
import time
from digitaltwin import Scene, Workflow,Editor
import digitaltwin_data
from threading import Thread
import os

projection = [
  [2393.230224609375,0.0,951.794189453125],
  [0.0,2393.364501953125,558.6798095703125],
  [0.0,0.0,1.0]]

eye_to_hand_transform = [
  [0.08766222494286922,0.9954482545931286,0.037391265631955106,0.7793440568869567],
  [0.9619166950744155,-0.09434572446817567,0.25654464720919273,-0.2510889858020945],
  [0.258904627334428,0.013478008089797142,-0.9658088512965427,1.2629839393068865],
  [0.0,0.0,0.0,1.0]]

data_dir = digitaltwin_data.get_data_path()

scene = Scene(1024, 768)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/算法插件.json'))

def updating():
  import time
  while True:
    scene.update_for_tick(1/180.)
    time.sleep(1/180.)

t = Thread(target=updating)
t.start()

scene.active_objs_by_name['camera'].set_calibration(projection,eye_to_hand_transform)
editor.add_cube([0,0,-0.7],[0,0,0],[0.5,0.5,0.7])

import pymeshlab as meshlab
ms = meshlab.MeshSet()
ms.load_new_mesh('./20230530194453412/Builder/foreground/output/20230530194453412.ply')
m = ms.current_mesh()
vs = m.vertex_matrix()
fs = m.face_matrix()
vcs = m.vertex_color_matrix()[:,:3]
```

```
scene.active_objs_by_name['camera'].draw_point_cloud(vs,vcs)
scene.active_objs_by_name['camera'].clear_point_cloud()
```

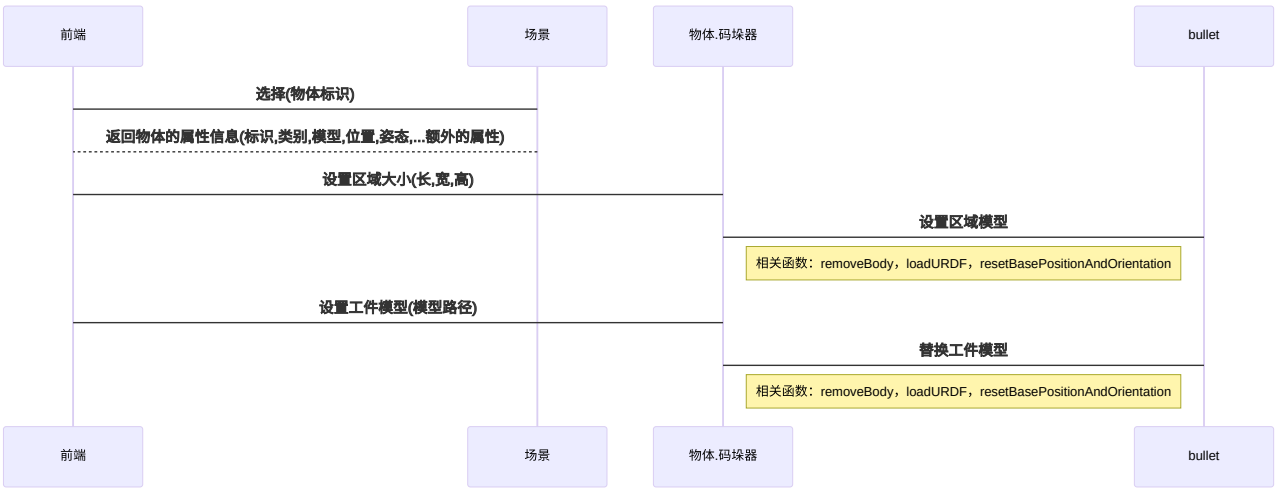
C++

```cpp
#include <opencv2/opencv.hpp>
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/标定测试.json");

    auto objs = scene->get_active_objs();
    auto camera = dynamic_cast<Camera3DReal*>(objs["camera"]);

    auto intrinsics = "[[2393.230224609375,0.0,951.794189453125],
[0.0,2393.364501953125,558.6798095703125],[0.0,0.0,1.0]]";
    auto extrinsics = "
[[0.08766222494286922,0.9954482545931286,0.037391265631955106,0.7793440568869567],
[0.9619166950744155,-0.09434572446817567,0.25654464720919273,-0.2510889858020945],
[0.258904627334428,0.013478008089797142,-0.9658088512965427,1.2629839393068865],
[0.0,0.0,0.0,1.0]]";

    camera->set_calibration(intrinsics,extrinsics);
    camera->set_rtt_func([](vector<unsigned char>& rgb_pixels,vector<float>& depth_pixels,int&
width,int& height) {
        width = 1024,height = 768;
        std::string sRGBFilePath = "./20230322110752009.png";
        cv::Mat rgbMat = cv::imread(sRGBFilePath);
        rgb_pixels = rgbMat.reshape(1,1);

        std::string sDepthFilePath = "./20230322110752009.tiff";
        cv::Mat depthMat = cv::imread(sDepthFilePath, cv::IMREAD_ANYDEPTH);
        depth_pixels = depthMat.reshape(1,1);

        width = rgbMat.cols;
        height = rgbMat.rows;
        return true;
    });

    Texture texture;
    camera->rtt(texture);
```

```
    return 0;
}
```

物体.码垛器

用于生成码放有序的工件。



Python

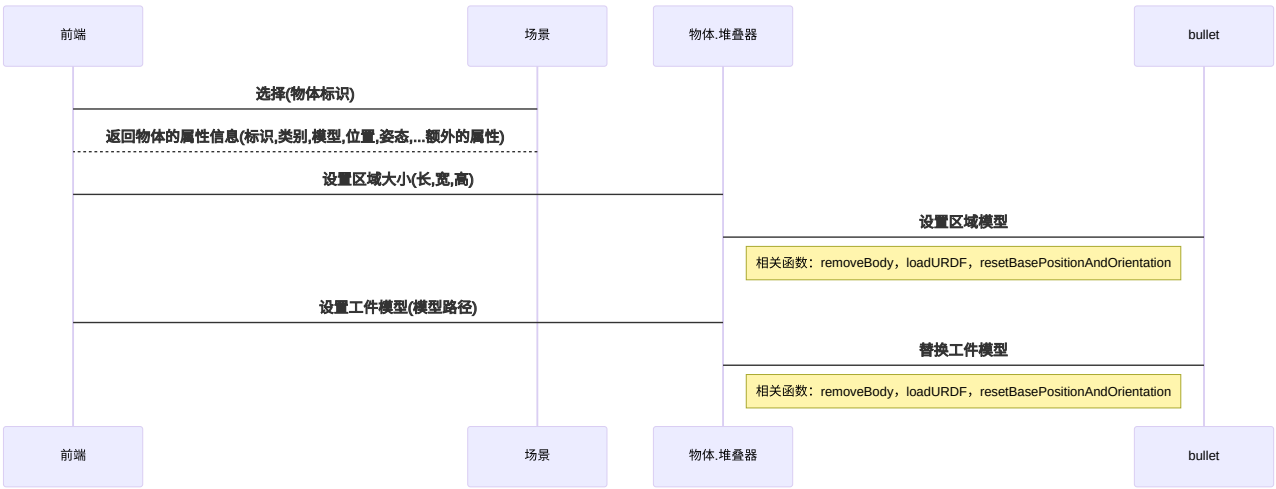
```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/混合拆垛.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

stacker = scene.active_objs_by_name['stacker']
stacker.generate()
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/混合拆垛.json");

    auto objs = scene->get_active_objs();
    auto stacker = dynamic_cast<Stacker*>(objs["stacker"]);
    stacker->signal("generate","");
    return 0;
}
```

物体.放置器

用于生成码放无序的工件。



Python

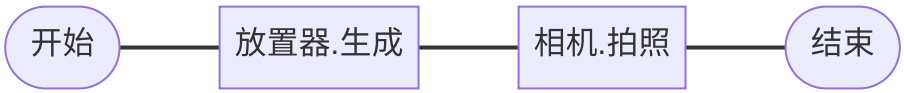
```python
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time

data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
scene.load(os.path.join(data_dir,'scenes/无序抓取.json'))

def updating():
    import time
    while True:
        scene.update_for_tick(1/180.)
        time.sleep(1/180.)

t = Thread(target=updating)
t.start()

placer = scene.active_objs_by_name['placer']
placer.generate()
```

C++

```cpp
#include "digitaltwin.hpp"
using namespace digitaltwin;

int main()
{
    auto scene = make_shared<Scene>
(1024,768,"./digitaltwin_data/engines/bullet","./digitaltwin_data");
    auto editor = make_shared<Editor>(scene.get());
    scene->load("./digitaltwin_data/scenes/混合拆垛.json");

    auto objs = scene->get_active_objs();
    auto placer = dynamic_cast<Placer*>(objs["placer"]);
    placer->signal("generate","");
    return 0;
}
```

工作流-示例-深度图/姿态估计/混合拆垛/无序抓取

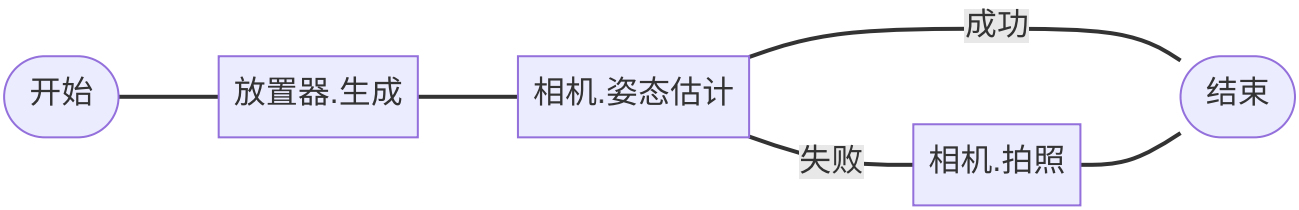
通过简单的两个节点来实现获取深度图的工作流，如下：




```
scene_profile = {
  "active_objects": [{
      "kind":"Placer",
      "name":"placer",
      "base":"./data/objects/tray/traybox.urdf",
      "pos":[0,-0.5,0.001],
      "rot":[0,0,0],
      "center":[0.0,-0.5,0.25],
      "interval":0.1,
      "amount":30,
      "workpiece":"./data/workpieces/lego/lego.urdf"
    },{
      "kind":"Camera3D",
      "name":"camera",
      "base":"./data/cameras/camera3d.urdf",
      "pos":[-0.5,-0.5,0.0],
      "rot":[0.0,0.0,-1.57],
      "fov": 45,
      "forcal": 0.01,
      "image_size": [300,300],
      "image_path":"./guagua.png"
    }
  ],

  "workflow":{
    "run":"1",
    "declare":{
      "1":{"kind":"Packer","fun":"generate","name":"placer","next":"2"},
      "2":{"kind":"Camera","fun":"capture","name":"camera"}
    }
  }
}
```

```
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time


data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
workflow = Workflow(scene)
scene.load(os.path.join(data_dir,'scenes/深度图.json'))


def updating():
  while True:
    scene.update_for_tick(1/180.)
    time.sleep(1/180.)

t = Thread(target=updating)
t.start()

workflow.start()
```

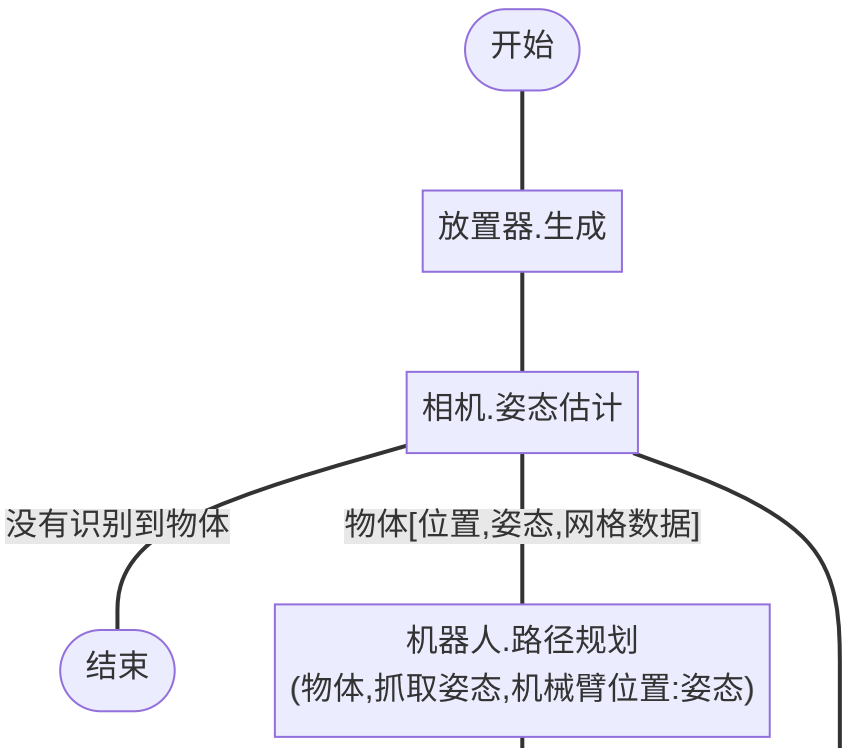
节点有时因为一些限制参数会返回失败，为应对于不同情况，可以采用分支来进行控制。假设姿态估计失败就拍照，如下：

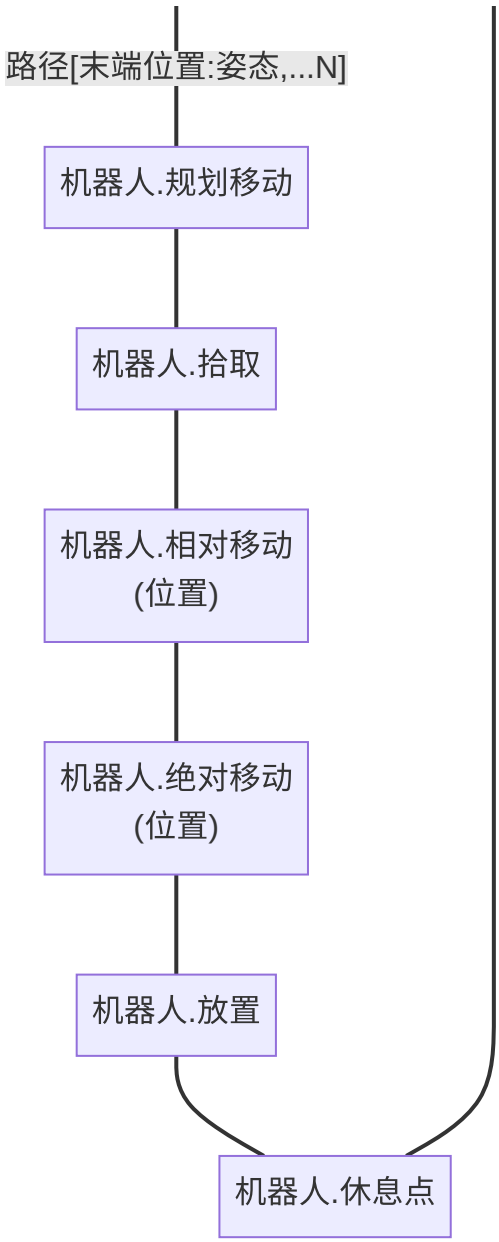


```
scene_profile = {
  "active_objects": [
    {
      "kind":"Placer",
      "name":"placer",
      "base":"./data/objects/tray/traybox.urdf",
      "pos":[0,-0.5,0.001],
      "rot":[0,0,0],
      "center":[0.0,-0.5,0.25],
      "interval":0.1,
      "amount":10,
      "workpiece":"./data/workpieces/lego/lego.urdf"
    },
    {
      "kind":"Camera3D",
      "name":"camera",
      "base":"./data/cameras/camera3d.urdf",
      "pos":[-0.5,-0.5,0.0],
      "rot":[0.0,0.0,-1.57],
      "fov": 20,
      "forcal": 0.01,
      "sample_rate": 20,
      "image_size": [300,300]
    }
  ],
  "workflow":{
    "run":"1",
    "declare":{
      "1":{"kind":"Placer","fun":"generate","name":"placer","next":"2"},
      "2":{"kind":"Camera","fun":"pose_recognize","name":"camera",
        "alt":[
          {"next":"3","err":"failed"}
        ]
      },
      "3":{"kind":"Camera","fun":"capture","name":"camera"}
    }
  }
}
```

```
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time


data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
workflow = Workflow(scene)
scene.load(os.path.join(data_dir,'scenes/姿态估计.json'))


def updating():
  while True:
    scene.update_for_tick(1/180.)
    time.sleep(1/180.)

t = Thread(target=updating)
t.start()

workflow.start()
```

接着，设计一个混合拆垛工作流，加入机器人进行分拣工作，如下：



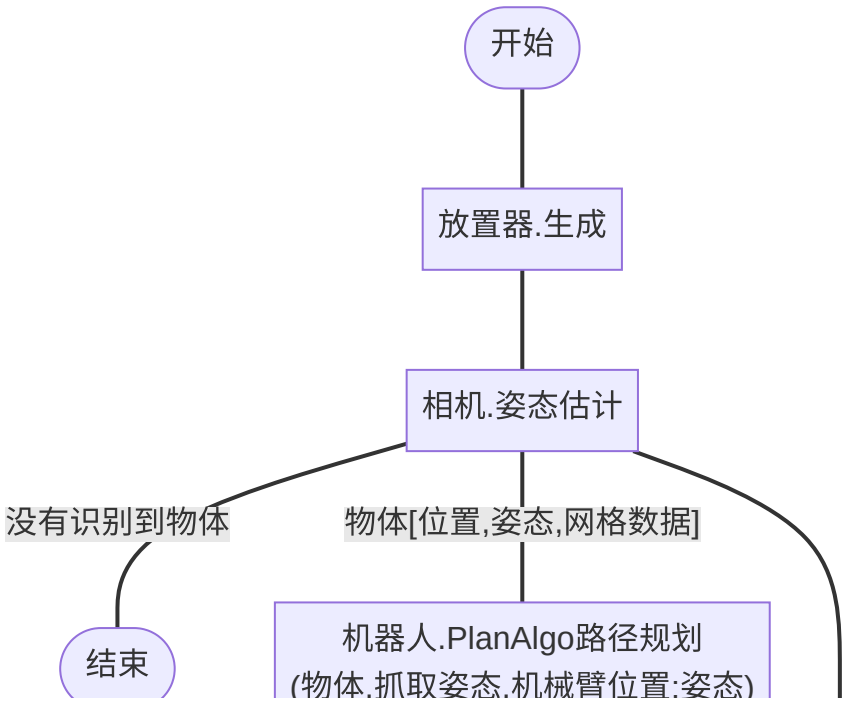

路径[末端位置:姿态,...N]
机器人.规划移动
机器人.拾取
机器人.相对移动(位置)
机器人.绝对移动(位置)
机器人.放置
机器人.休息点

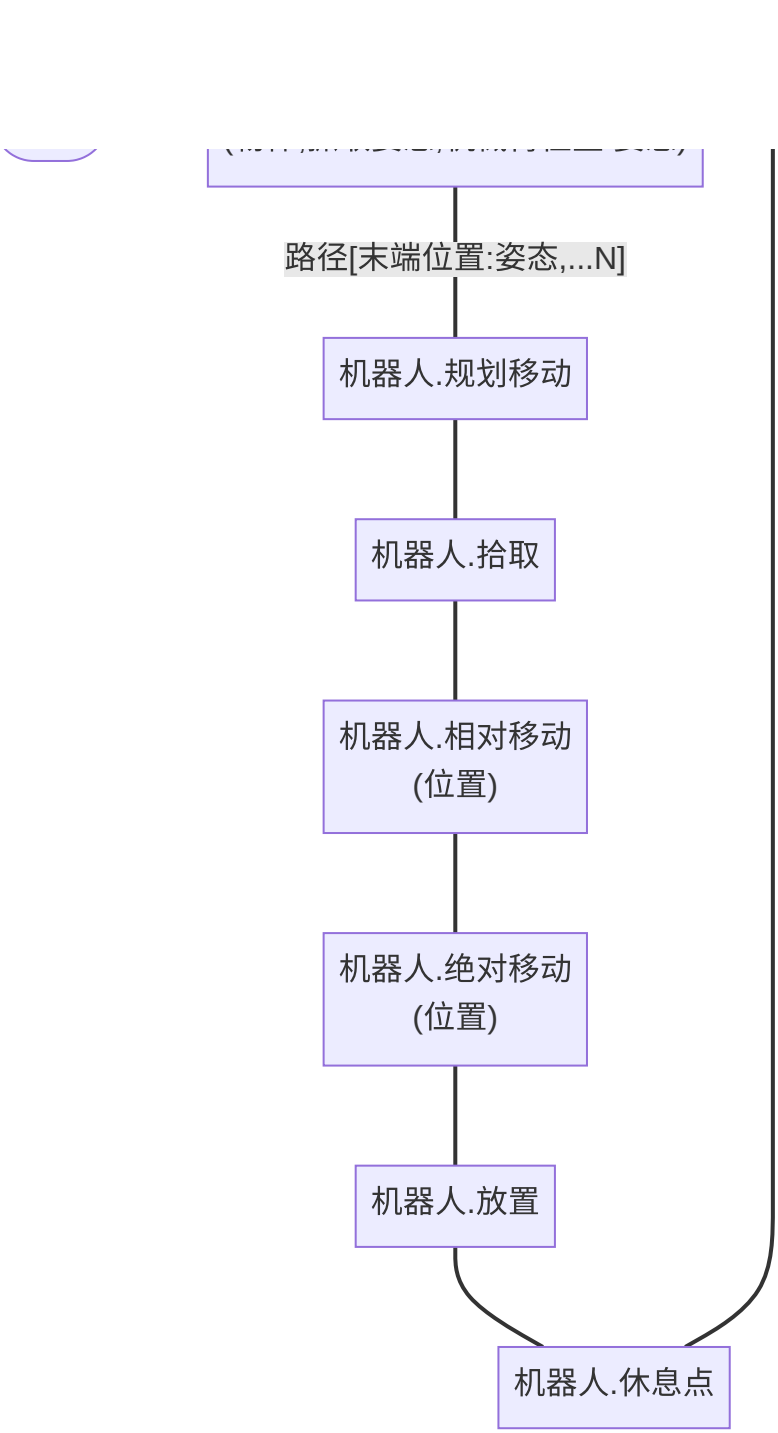
```
# 格式：json
scene_profile={
  "active_objects": [
    {
      "kind":"Robot",
      "name":"robot",
      "base":"./data/robots/ur5/ur5.urdf",
      "pos":[0,0,0],
      "rot":[0,0,3.14],
      "reset_joint_poses":[-1.57,0.0,-0.3925,-0.785,1.57,0],
      "joint_damping":[ 0, 1, 0.9, 0.8, 0.7, 0.0],
      "end_effector":"./data/end_effectors/suction/suction.urdf"
    },
    {
      "kind":"Stacker",
      "name":"stacker",
      "base":"./data/objects/tray/traybox.urdf",
      "pos":[0,-0.52,0.01],
      "rot":[0,0,0],
      "area":[0.3,0.3,0.3],
      "box_size":[0.1,0.1,0.05],
      "random_factor":[0.2,0.2,0.0]
    },
    {
      "kind":"Camera3D",
      "name":"camera",
      "base":"./data/cameras/camera3d.urdf",
      "pos":[-0.5,-0.52,0.0],
      "rot":[0.0,0.0,-1.57],
      "fov": 20,
      "forcal": 0.01,
      "sample_rate": 20,
      "image_size": [300,300],
      "image_path":"./guagua.png"
    }
  ],

  "workflow": {
    "run":"1",
    "declare":{
      "1":{"kind":"Stacker","fun":"generate","name":"stacker", "next":"2"},
      "2":{
        "kind":"Camera3D","fun":"pose_recognize","name":"camera", "next":"3",
```

```
          "alt":[
            {"next":"7","err": "failed"}
          ]
        },
        "3":{"kind":"Robot","fun":"pick_plan","name":"robot","next":"4","args":{
          "pick_poses":[
            {"pos":[0.0,0.0,0.024],"rot":[0,0,0]}
          ]
        }},
        "4":{"kind":"Robot","fun":"plan_move","name":"robot","next":"5"},
        "5":{"kind":"Robot","fun":"do","name":"robot","args":{"pickup": true},"next":"6"},
        "6":{"kind":"Robot","fun":"move_relatively","name":"robot","args":
{"x":0.0,"y":0.0,"z":0.1},"next":"7"},
        "7":{"kind":"Robot","fun":"move","name":"robot","args":{"x":0.5,"y":0.0,"z":0.5},"next":"8"},
        "8":{"kind":"Robot","fun":"do","name":"robot","args":{"pickup": false},"next":"9"},
        "9":{"kind":"Robot","fun":"home","name":"robot","next":"2"}
      }
    }
}
```

```
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time


data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
workflow = Workflow(scene)
scene.load(os.path.join(data_dir,'scenes/混合拆垛.json'))


def updating():
  while True:
    scene.update_for_tick(1/180.)
    time.sleep(1/180.)

t = Thread(target=updating)
t.start()

workflow.start()
```

最后，设计一个无序抓取的工作流，因为内置算法太垃圾，在此加入第三方路径规划算法，如下：




路径[末端位置:姿态,...N]
机器人.规划移动
机器人.拾取
机器人.相对移动(位置)
机器人.绝对移动(位置)
机器人.放置
机器人.休息点

```
scene_profile={
  "active_objects": [
    {
      "kind":"Robot",
      "name":"robot",
      "base":"./data/robots/ur5/ur5.urdf",
      "pos":[0,0.1,0],
      "rot":[0,0,3.14],
      "reset_joint_poses":[-1.57,0.0,-0.3925,-0.785,1.57,0],
      "joint_damping":[ 0, 1, 0.9, 0.8, 0.7, 0.0],
      "end_effector":"./data/end_effectors/gripper/gripper.urdf"
    },
    {
      "kind":"Placer",
      "name":"placer",
      "base":"./data/objects/tray/traybox.urdf",
      "pos":[0,-0.5,0.001],
      "rot":[0,0,0],
      "center":[0.0,-0.5,0.25],
      "interval":0.1,
      "amount":10,
      "workpiece":"./data/workpieces/suction/suction.urdf",
      "workpiece_texture":""
    },
    {
      "kind":"Camera3D",
      "name":"camera",
      "base":"./data/cameras/camera3d.urdf",
      "pos":[-0.5,-0.5,0.0],
      "rot":[0.0,0.0,-1.57],
      "fov": 20,
      "forcal": 0.01,
      "sample_rate": 20,
      "image_size": [300,300],
      "image_path":"./guagua.png"
    }
  ],

  "workflow":{
    "run":"1",
    "declare":{
      "1":{"kind":"Placer","fun":"generate","name":"placer", "next":"2"},
      "2":{
```

```
          "kind":"Camera3D","fun":"pose_recognize","name":"camera", "next":"3",
          "alt":[{"next":"7","err": "failed"}]
        },
        "3":{"kind":"Robot","fun":"pick_plan","name":"robot","args":{
          "pick_poses":[
            {"pos":[0.0,0.0,0.01],"rot":[0,1.57,0]},
            {"pos":[0.0,0.0,0.01],"rot":[0,1.57,-0.785]},
            {"pos":[0.0,0.0,0.01],"rot":[0,1.57,-1.57]},
            {"pos":[0.0,0.0,0.01],"rot":[0,1.57,-2.355]},
            {"pos":[0.0,0.0,0.01],"rot":[0,1.57,-3.14]},
            {"pos":[0.0,0.0,0.01],"rot":[0,1.57,2.355]},
            {"pos":[0.0,0.0,0.01],"rot":[0,1.57,1.57]},
            {"pos":[0.0,0.0,0.01],"rot":[0,1.57,0.785]}
          ]
        },"next":"4"},
        "4":{"kind":"Robot","fun":"plan_move","name":"robot","next":"5"},
        "5":{"kind":"Robot","fun":"do","name":"robot","args":{"pickup":true},"next":"6"},
        "6":{"kind":"Robot","fun":"move_relatively","name":"robot","args":
{"x":0.0,"y":0.0,"z":0.35},"next":"7"},
        "7":{"kind":"Robot","fun":"move","name":"robot","args":{"x":0.3,"y":0.1,"z":0.3},"next":"8"},
        "8":{"kind":"Robot","fun":"do","name":"robot","args":{"pickup": false},"next":"9"},
        "9":{"kind":"Robot","fun":"home","name":"robot","next":"2"}
      }
    }
}
```

```
from threading import Thread
from digitaltwin import Scene,Workflow,Editor
import digitaltwin_data
import os
import time


data_dir = digitaltwin_data.get_data_path()
scene = Scene(1024,768,data_dir)
editor = Editor(scene)
workflow = Workflow(scene)
scene.load(os.path.join(data_dir,'scenes/无序抓取.json'))


def updating():
  while True:
    scene.update_for_tick(1/180.)
    time.sleep(1/180.)

t = Thread(target=updating)
t.start()

workflow.start()
```

工作流-获取活动节点

绘制流程图前，前端需要知道流程图由多少种节点构成，通过这个函数可以得到场景中所有可用的节点及功能，并用名字区分实体。

```
[
  {'kind':'Robot','names':[],'funs':[
    {'label':'Motion', #动作
      'f':'pick_move','errs':[], #拾取移动
      'args':[ #附加参数
        {'name':'mode','kind':'String'}, #运动模式，关节：joint 线：linear
        {'name':'speed','kind':'Flaot'}, #速度，0.0 ~ 1.0
        {'name':'pickup','kind':'Bool'}, #拾取设置
        {'name':'vision_flow','kind':'String'} #视觉流程
      ]},
    {'label':'Motion', #动作
      'f':'move','errs':[], #移动
      'args':[ #附加参数
      {'name':'mode','kind':'String'}, #运动模式，关节：joint 线：linear
      {'name':'speed','kind':'Flaot'}, #速度，值：0.0 ~ 1.0，默认：0.2
      {'name':'pickup','kind':'Bool'}, #拾取设置
      {'name':'joints','kind':'List'}, #关节位置，[弧度值1,...弧度值n]
      {'name':'point','kind':'List'}, #点位置，[x,y,z,rx,ry,rz] #米，弧度
      {'name':'home','kind':'Bool'}, #回到休息点，为true，忽略其他参数
      ]},
    {'label':'Motion', #动作
      'f':'move_relatively','errs':[], #相对移动
      'args':[ #附加参数
        {'name':'mode','kind':'String'}, #模式，关节：joint 线：linear
        {'name':'speed','kind':'Flaot'}, #速度，值：0.0 ~ 1.0，默认：0.2
        {'name':'pickup','kind':'Bool'}, #拾取设置
        {'name':'target','kind':'String'}, #相对目标，当前任务：task_current，下一个任务：task_next，选择的任务：selected，工具坐标系：frame_end_effector，机械臂坐标系：frame_robot，全局坐标系：frame_global
        {'name':'point','kind':'List'}, #点位置，[x,y,z,rx,ry,rz] #米，弧度
      ]},
    {'label':'EndEffector',
      'f':'pick','errs':[], #开
      'args':[]},
    {'label':'EndEffector',
      'f':'place','errs':[], #合
      'args':[]}
    ]},
  {'kind':'Camera3DReal','names':[],'funs':[ #相机
    {'label':'Vision','f':'capture','errs':["failed"],'args':[ #拍照
      {'name':'wait_for_seconds','kind':'Float'}] #等待时间
    }
    ]},
```

```
  {'kind':'Camera3D','names':[],'funs':[  #相机
    {'label':'Vision','f':'capture','errs':["failed"],'args':[ #拍照
      {'name':'wait_for_seconds','kind':'Float'}] #等待时间
    }
    ]},
  {'kind':'Placer','names':[],'funs':[{'label':'PlacingContainer','f':'generate','errs':["failed"],'args':[]}]}, #
放置器
  {'kind':'Stacker','names':[],'funs':[{'label':'StackingContainer','f':'generate','errs':["failed"],'args':[]}]},
#堆垛器
  {'kind':'Vision','names':['PickLight'],'funs':[
    {'label':'Vision','f':'detect','errs':[],'args':[ #视觉检测
      {'name':'vision_flow','kind':'String'}]} #视觉流程，？？
    ]}
]
```

工作流-获取/设置

前端要去绘制一个场景的工作流程时，首先要去调用获取函数得到流程信息（中文翻译由前端完成）。修改完流程后调用设置函数去保存工作流程信息。

工作流-启动/停止

让整个场景工作起来，调用启动函数。需要突然终止则调用停止函数。