6、Augmented Reality

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Function package：~/orbbec_ws/src/astra_visual

6.1、Overview

Augmented Reality ("AR"), is a technology that ingeniously integrates virtual information with the real world. It extensively uses a variety of technical means such as multimedia, 3D modeling, real-time tracking and registration, intelligent interaction, sensing, etc., to simulate and apply computer-generated text, images, 3D models, music, video and other virtual information to the real world. In order to achieve the "enhancement" of the real world.

The AR system has three outstanding features: ①The information integration of the real world and the virtual world; ②It has real-time interactivity; ③It adds and locates virtual objects in the 3D space.

6.2、Application

When using the AR case, you must have the camera's internal reference, otherwise it will not work.

6.2.1、Start up launch

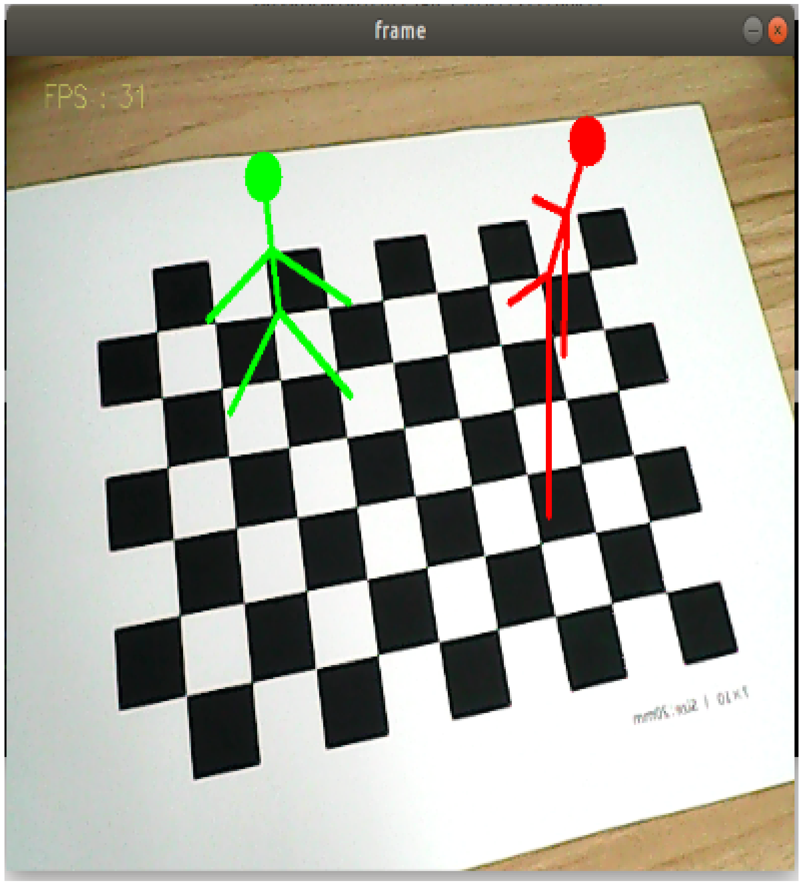
```
roslaunch orbbec_camera gemini2.launch  #start camera
roslaunch astra_visual astra_AR.launch  #Start function node
```

Note:【q】key to exit.

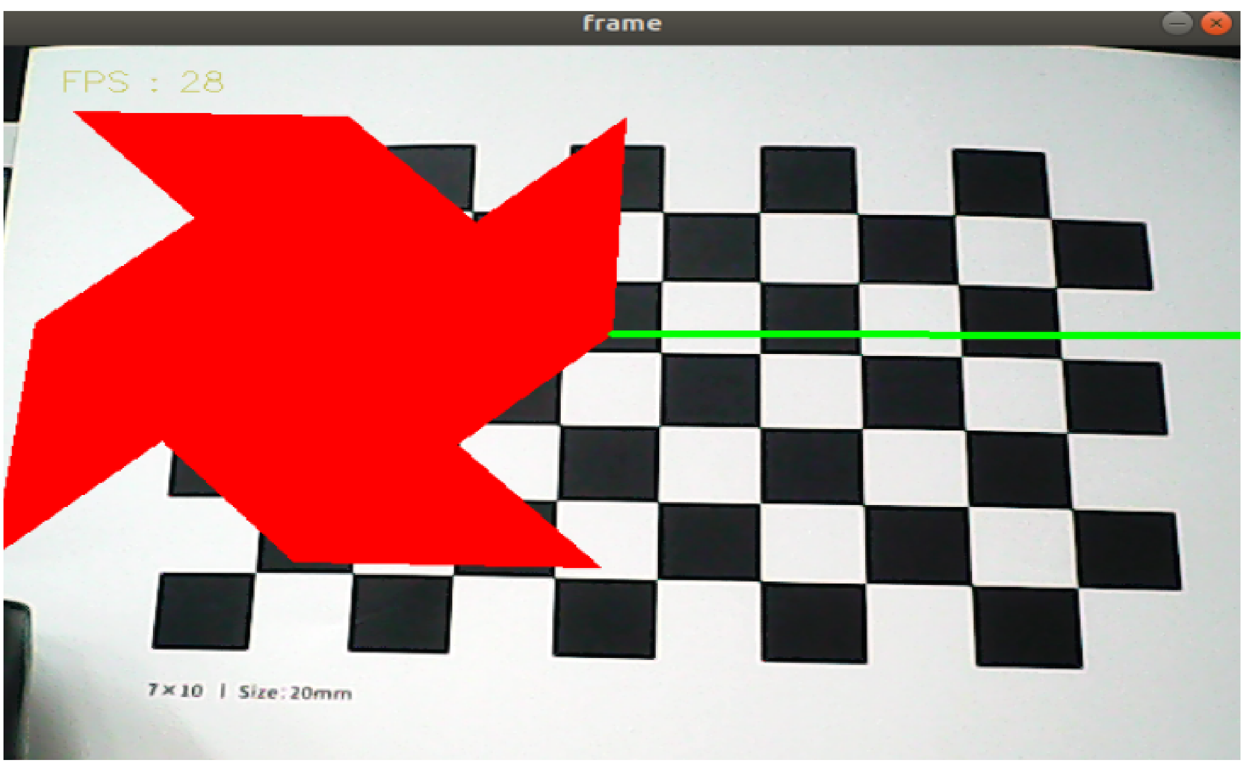
6.2.2、Effect demonstration

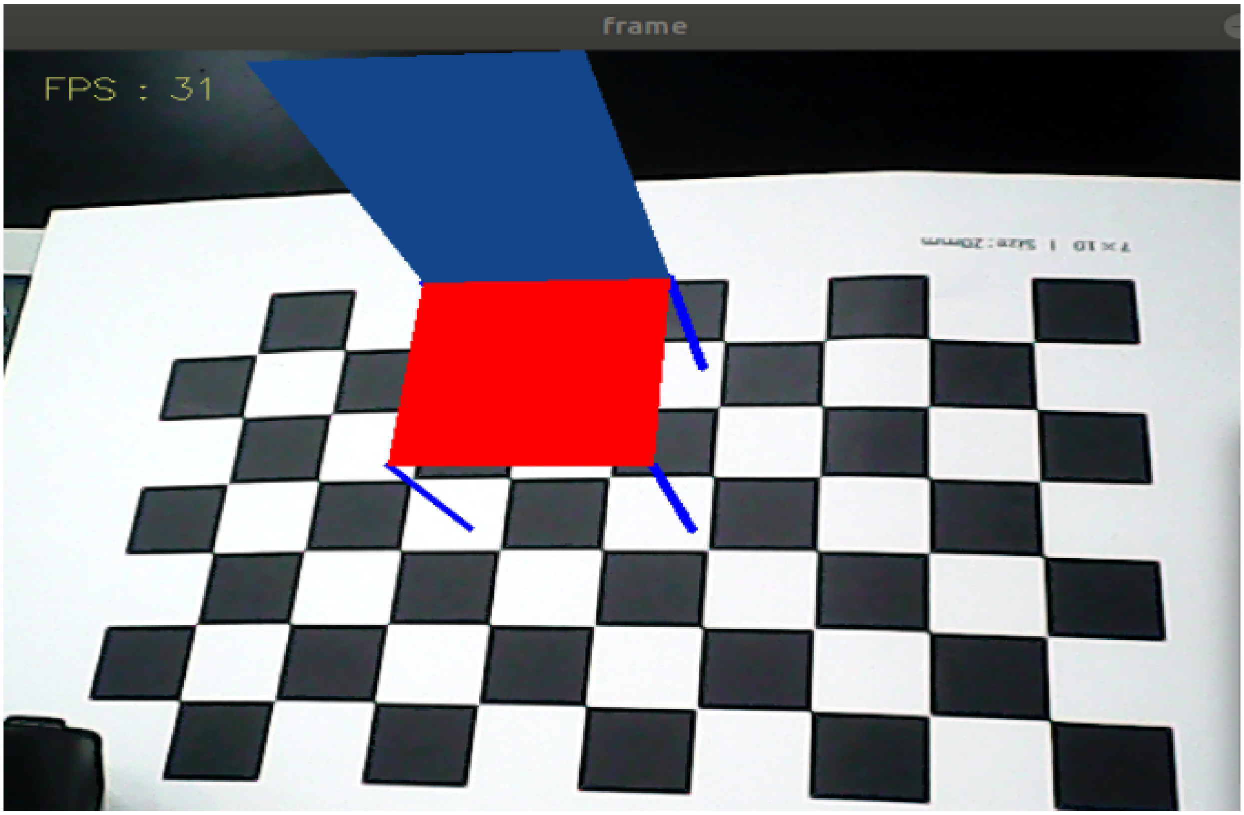
A total of 12 effects.

```
["Triangle", "Rectangle", "Parallelogram","WindMill","TableTennisTable", "Ball",
"Arrow", "Knife", "Desk",
"Bench", "Stickman", "ParallelBars"]
```



Press【F】key to switch between different effects.



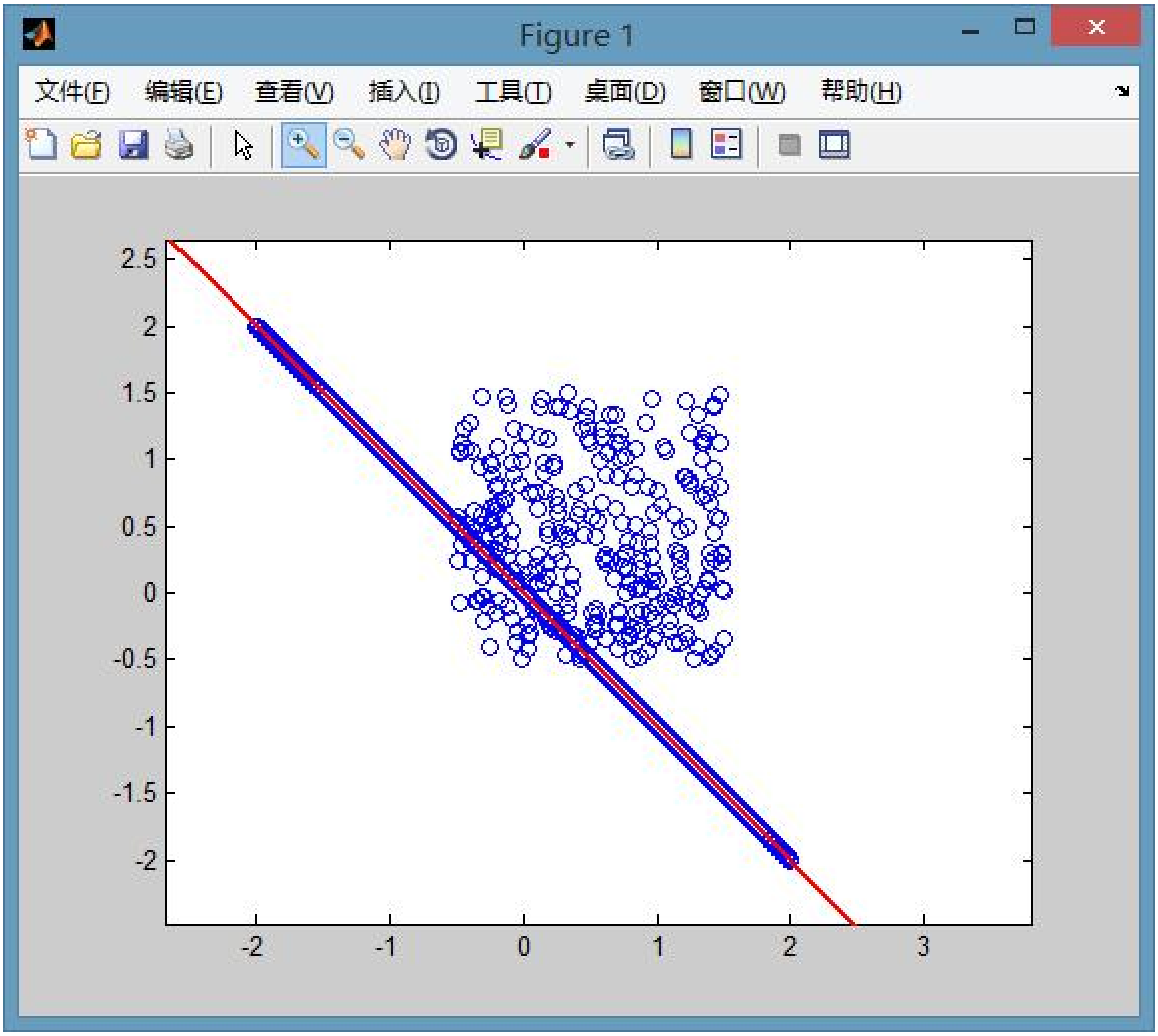


6.3、Code

6.3.1、Algorithm principle

Use the RANSAC scheme to find the object pose from the 3D-2D point correspondence.

The RanSaC algorithm is a classic algorithm for data processing. Its function is to extract specific components in an object under a large amount of noise. The following figure illustrates the effect of RanSaC algorithm. Some points in the figure obviously satisfy a certain straight line, and another group of points is pure noise. The purpose is to find a straight line equation in the presence of a lot of noise, at this time the amount of noise data is 3 times that of a straight line.



6.3.2、Code

launch file

```
<launch>
    <arg name="flip" default="False"/>
    <arg name="VideoSwitch" default="False"/>
    <node name="simple_AR" pkg="astra_visual" type="simple_AR.py" output="screen">
        <param name="flip" type="bool" value="$(arg flip)"/>
        <param name="VideoSwitch" type="bool" value="$(arg VideoSwitch)"/>
    </node>
</launch>
```

python main function

```
    def process(self, img):
        if self.flip == 'True': img = cv.flip(img, 1)
        gray = cv.cvtColor(img, cv.COLOR_BGR2GRAY)
        # Find the corner points of each picture
        retval, corners = cv.findChessboardCorners(
            gray, self.patternSize, None,
```

```
            flags=cv.CALIB_CB_ADAPTIVE_THRESH + cv.CALIB_CB_NORMALIZE_IMAGE +
cv.CALIB_CB_FAST_CHECK)
        # Find corner sub-pixels
        if retval:
            corners = cv.cornerSubPix(
                gray, corners, (11, 11), (-1, -1),
                (cv.TERM_CRITERIA_EPS + cv.TERM_CRITERIA_MAX_ITER, 30, 0.001))
            # Calculate object pose solvePnPRansac
            retval, rvec, tvec, inliers = cv.solvePnPRansac(
                self.objectPoints, corners, self.cameraMatrix, self.distCoeffs)
            # Output image points and Jacobian matrix
            image_Points, jacobian = cv.projectPoints(
                self.__axis, rvec, tvec, self.cameraMatrix, self.distCoeffs, )
            # Draw image
            img = self.draw(img, corners, image_Points)
        return img
```

More function:

https://docs.opencv.org/3.0-alpha/modules/calib3d/doc/camera_calibration_and_3d_reconstruction.html

- findChessboardCorners()

```
def findChessboardCorners(image, patternSize, corners=None, flags=None):
    '''
   Find the corner points of each picture
    :param image: Enter the original checkerboard image. The image must be an 8-bit
grayscale image or color image.
    :param patternSize: (w,h)，The number of inner corners in each row and column on
the chessboard. w=the number of black and white blocks on a row of the chessboard
-1, h=the number of black and white blocks on a column of the chessboard -1.
    For example: 10x6 chessboard, then (w,h)=(9,5)
    :param corners: array，The output array of the detected corner points.
    :param flags: int,Different operation flags can be 0 or a combination of the
following values:
    CALIB_CB_ADAPTIVE_THRESH Use the adaptive threshold method to convert the image
to black and white instead of using a fixed threshold.
    CALIB_CB_NORMALIZE_IMAGE Before using fixed threshold or adaptive threshold to
binarize the image, use histogram to equalize the image.
    CALIB_CB_FILTER_QUADS Use additional criteria (such as contour area, perimeter,
square shape) to filter out the false quadrilaterals extracted in the contour
retrieval stage.
    CALIB_CB_FAST_CHECK Run a quick check mechanism on the image to find the corners
of the board, and return a quick reminder if no corners are found.
    When the chessboard is not observed, the call under degraded conditions can be
greatly accelerated.
    :return: retval, corners
    '''
    pass
```

- cornerSubPix()

We need to use cornerSubPix() to perform further optimization calculations on the detected corners, so that the accuracy of the corners can reach the sub-pixel level.。

```
def cornerSubPix(image, corners, winSize, zeroZone, criteria):
    '''
   Sub-pixel corner detection function
    :param image: Input image
    :param corners: Pixel corners (both as input and output)
    :param winSize: The area size is NXN; N=(winSize*2+1)
    :param zeroZone: Similar to winSize, but always has a smaller range, Size(-1,-1) 
means ignore
    :param criteria: Stop optimization criteria
    '''
    pass
```

- solvePnPRansac()

```
def solvePnPRansac(objectPoints, imagePoints, cameraMatrix, distCoeffs,
                   rvec=None, tvec=None, useExtrinsicGuess=None, 
iterationsCount=None,
                   reprojectionError=None, confidence=None, inliers=None, 
flags=None):
    '''
    Calculate object pose
    :param objectPoints: Object point list
    :param imagePoints:  Corner list
    :param cameraMatrix: Camera matrix
    :param distCoeffs:   Distortion coefficient
    :param rvec:
    :param tvec:
    :param useExtrinsicGuess:
    :param iterationsCount:
    :param reprojectionError:
    :param confidence:
    :param inliers:
    :param flags:
    :return: retval, rvec, tvec, inliers
    '''
    pass
```

The RANSAC scheme is used to find the object pose from the 3D-2D point correspondence. This function estimates the pose of the object given a set of object points, their corresponding image projections, camera matrix and distortion coefficients. This function finds a pose that minimizes the re-projection error, that is, the re-observation error, that is, the sum of the squared distances between the observed pixel point projection imagePoints and the object projection (`projectPoints()`) objectPoints. The use of RANSAC can avoid the influence of outliers on the results.

- projectPoints()

```python
def projectPoints(objectPoints, rvec, tvec, cameraMatrix, distCoeffs,
imagePoints=None, jacobian=None, aspectRatio=None):
    '''
    Output image points and Jacobian matrix
    :param objectPoints:
    :param rvec:   Rotation vector
    :param tvec:   Translation vector
    :param cameraMatrix:  Camera matrix
    :param distCoeffs:    Distortion coefficient
    :param imagePoints:
    :param jacobian:
    :param aspectRatio:
    :return: imagePoints, jacobian
    '''
    pass
```