A Deep Learning Approach to Camera Pose Estimation

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Abstract—Camera pose estimation aims to find the absolute position of the camera within a given frame of a video. The estimation can be use in may ways, from object identification inside a known environment, to feature extraction combined with pose for 3D reconstruction.

Index Terms—component, formatting, style, styling, insert

I. Introduction

The camera pose can be expressed through two component:

1) a tuple of three elements that identifies the coordinates x,y and z

$$x_c = (x, y, z) \quad x, y, z \in \mathbb{R}$$
 (1)

2) a quaternion of four elements that identifies the rotation of the camera

$$q_c = (qw, qx, qy, qz) \quad qw, qx, qy, qz \in \mathbb{R}$$
 (2)

Consequentially the pose is referred as $p_c = (x_c, q_c)$. It is important to notice that this is not the only available representation of a pose.

Given an image I_c captured by a camera C, an absolute pose estimator E tries to predict the 3D pose orientation and location of C in world coordinates, defined for some arbitrary reference 3D model. The *absolute pose estimation* (APE) problem can be formally defined as the problem of estimating a function E taking an image I_c caputered by a camera C and outputting its respective pose:

$$E(I_c) = (x_c, q_c) \tag{3}$$

Another problem related to APE is relative pose estimation (RPE), in this kind of task the estimator takes two image I_c^1 and I_c^2 captured by C and aims to predict the relative pose between them. The eq. (3) becomes:

$$E(I_c^1, I_c^2) = (x_c^{rel^2}, q_c^{rel})$$
(4)

where x_c^{rel} can be the absolute pose with coordinates reference system in I_c^1 or a translation vector from I_c^1 to I_C^2 .

II. STATE OF ART

III. DATASET GENERATION

A. Approaches tested

The deep learning approaches explained in this document are *supervised learning* techniques that require a labeled dataset. Several paths were tested in order to generate this kind of dataset:

- IMU sensors: usage of gyroscope and accelerometer sensors of a smarthphone to estimate the position of the camera during a video given a fixed origin point.
- digital video: usage of free online 3 dimensional datasets in which video can be recorder in a digital way.
- motion capture system: usage of a motion capture system that estimates the camera position following some tracking objects attached to the subject.
- structure from motion techniques: techniques that computes a sparse and dense reconstruction from a sequence of images.

The main problem encountered with IMU sensors was the high noise presents during acquisitions, the final signal was very dirty and the resolution was not acceptable for the dataset generation. A possible solution could have been the usage of a well calibrated hardware used in other kind of contexts.

Most of the 3 dimensional acquisitions available online for free are acquired with *depth sensors* or *LIDAR sensors*, for this reason although the camera pose estimation would not have presented any errors the images would have been at low quality.

The motion capture system is able to follows the position of the tracked objects with extremely precision, the main problematic remains the associated of poses to video captured from the camera held by the tracked subject. Other difficulties involved the calibration of the tool.

The techniques of structure from motion were invented with the goal of generate structures for which a huge amount of photos is available. The overall idea is to feed the algorithm with data in order to extract feature and build a recomposition of the environment. A step required in order to obtain a result is the esimation of the pose of images. These intermediate requirement have been exploited by uus to generate a labeled dataset.

B. Pipeline

The implemented pipeline require a video captured by any camera, it is not required any calibration of the sensor. It is composed by several steps:

- 1) video split: the captured video is split into many frames;
- structure from motion: images obtained from the previous step are fed into a structure motion tool called COLMAP;
- 3) cross validation dataset: positions obtained during the camera estimation of the reconstruction process are split into three batches: train, validation, test.

IV. Models

V. RESULTS

VI. CONCLUSION

VII. EASE OF USE

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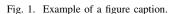


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ACKNOWLEDGMENT

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