

Abstract

Visual geo-localization methods are aimed to exploit visual information contained in visual multimedia to estimate camera parameters. These methods are mainly focused on, but not limited to estimation of camera position, orientation and field-of-view. Despite advances in computer vision in recent years, visual geo-localization is still far from being a solved problem. Project Locate (cadik.posvete.cz/locate/) focuses on several subtopics, which include estimation of camera orientation given known position, camera pose estimation, camera elevation estimation, evaluation of existing visual geo-localization methods, and computational photography applications. The main idea of our research is to use data from geographic information systems (GIS) for cross-domain alignment of a photo and a terrain rendered from a digital elevation model (DEM). Taking advantage of GIS data and DEM, we developed novel methods for camera orientation and elevation estimation, and also a dataset GeoPose3K. GeoPose3K is a novel evaluation benchmark for visual geo-localization methods in mountainous environments.

Abstrakt

Metody vizuální geo-lokalizace jsou zaměřeny na využití vizuální informace obsažené v obrazových multimédiích k odhadu parametrů kamery. Tyto metody jsou převážně zaměřeny na odhad pozice kamery, orientace a úhlu záběru. Přes pokroky počítačového vidění v minulých letech zůstávají metody vizuální geo-lokalizace nevyřešeným problémem. Projekt Locate (cadik.posvete.cz/locate/) je zaměřen na několik podtémat, které zahrnují odhad orientace kamery při známé pozici, odhad pózy kamery, odhad nadmořské výšky z obrazu, vyhodnocení existujících geo-lokalizačních metod a aplikace výpočetní fotografie. Hlavní myšlenka našeho výzkumu spočívá ve využití dat geografických informačních systémů (GIS) pro mezi-doménové zarovnávání fotografie s terénem renderovaným z digitálního výškového modelu (DEM). S využitím GIS dat a DEM jsme vyvinuli nové metody pro odhad orientace a nadmořské výšky kamery, a také dataset GeoPose3K. GeoPose3K je nový benchmark pro vyhodnocení metod vizuální geo-lokalizace v horských oblastech.

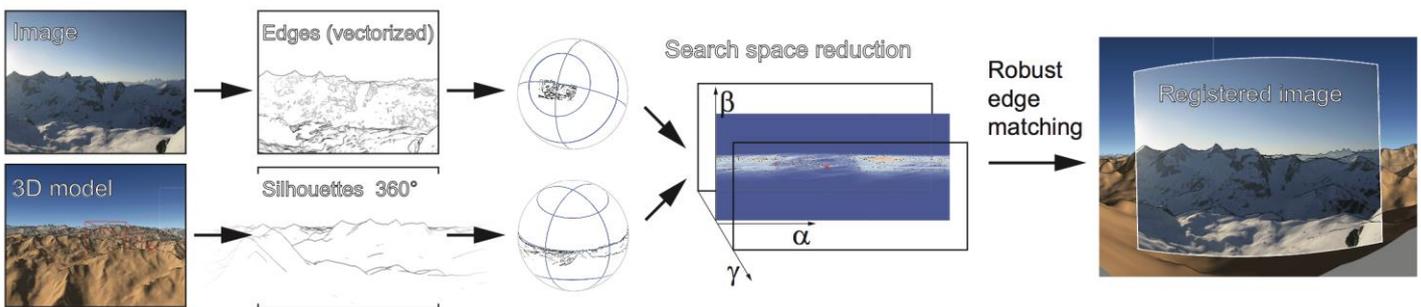


Figure 1: Camera orientation estimation using cross-domain image-to-digital terrain alignment.

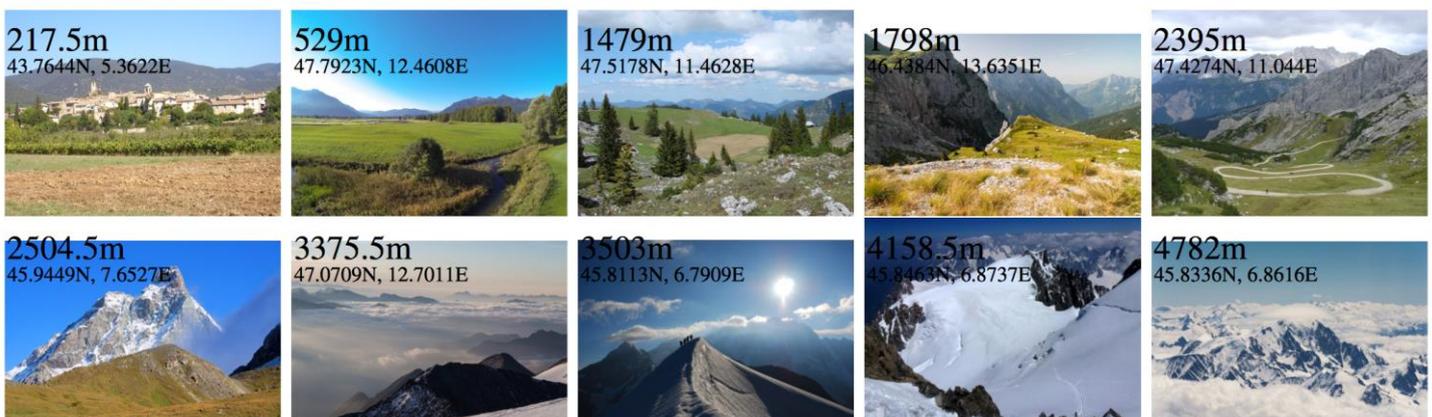


Figure 2: Sample images from camera elevation estimation dataset Alps100K (cphoto.fit.vutbr.cz/elevation/). Image credits - flickr users: Allie_Caulfield, Golf Resort Achenal Team, Erik, Guillaume Baviere, Tadas Balčiunas, antoine.pardigon, twiga269, Karim von Orelli.

Our Research

Visual geo-localization in outdoor environment is a challenging task, mainly because of rapidly changing weather, seasons, growing vegetation, or occlusions caused by clouds or fog. According to our survey on visual geo-localization, purely visual localization remains an open problem, especially in natural environments. While pursuing an ultimate goal of being able to localize any picture on the planet with a reasonable precision, we developed several methods. The first is an automatic camera orientation estimation method using alignment of image edges with a rendered digital elevation model (Figure 1). Being able to estimate camera orientation with given camera position is, however, much simpler task than general geo-localization, where the camera position is unknown. To restrict the enormous search space, our computational photography group (cphoto.fit.vutbr.cz) extensively researched the topic of camera elevation estimation. We combine several algorithms and propose a hybrid approach for camera elevation estimation using combination of Bag-of-Words, and Convolutional Neural Network model (Figure 2). Using estimate of camera elevation, the search space can be rapidly pruned taking into consideration only places having elevation near the estimate. To enable rapid development of new visual geo-localization methods, we assembled a dataset GeoPose3K, which consists of more than three thousands images with precisely annotated camera poses. With GeoPose3K, novel methods for visual geo-localization in natural areas can be trained and evaluated.

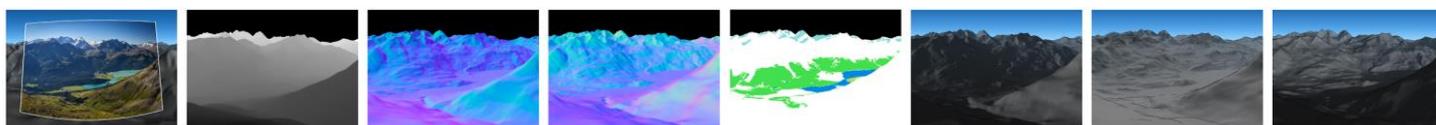


Figure 3: GeoPose3K dataset (cphoto.fit.vutbr.cz/geoPose3K/): for each mountain landscape photograph, the dataset contains (in reading order) its GPS coordinate and camera orientation, distance from the camera in meters, normals w.r.t. camera, normals w.r.t. cardinal direction, semantic labels and approximate illumination during the day (here shown at 5am, 12pm and 8pm).

Applications

Systems for organization and management of large scale datasets of photographs, such as Flickr.com are highly utilizing the knowledge of multimedia location. Images and videos might be sorted according to their position, which accelerates searching. Users can take advantage of photos visualized in the map, or in virtual and augmented reality for better understanding of the content. Sometimes, GPS information is not available for certain multimedia, such as old photographs. Methods dealing with problems such as historical rephotography need to estimate the camera position and orientation so that the evolution of a historical place can be tracked automatically. Systems for automatic image enhancement using computational photography techniques also make use of image location. Furthermore, autonomous vehicles and UAVs also depend on very precise knowledge of position and orientation in world space. Visual geo-localization methods improve reliability of such systems, since GPS can suffer from reception drops in areas with poor sky visibility.

Title: Locate - Visual Localization in Natural Env.
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