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USING PARALLEL ALGORITHMS FOR EFFICIENT SOLUTIONS TASKS SEARCH IN COMPUTER VISION

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Abstract: The article proposes new parallel algorithms for solving compliance problems images V computer vision. This industrial photogrammetric system, in which are used artificial reflective targets, gives significant advantage in time and exact solution tasks identical images.

Keywords: computer vision, photogrammetry, problem compliance, parallel algorithms, problem of maximum clique, epipolar geometry.

Introduction

Efficient matching between 3D object point images is also famous How problem compliance points, is one from key problems V computer vision [1]. There are several ways to solve the compliance problem, such How detection signs, method, founded on restrictions epipolar geometry, And combination these two methods. Detection signs is most a popular approach to solving the point matching problem. These methods analyze images and looking for elements, such How corners, ledges, contrasting points And T. d. A numeric value called a descriptor is calculated from the image data based on some surroundings of the object. This approach allows find point compliance almost instantly by matching the numerical values of the descriptors, since local element detectors resistant to most image transformations, caused by camera movement, given that lighting conditions remain unchanged and The camera position does not change fundamentally. Another advantage is That fact, What function detection Not requires knowledge relative provisions cameras.

Stage tasks

TO unfortunately, methods detection signs effective only at stable lighting If the light source moves, objects may change their appearance, structure shadows or disappear. This leads To changes numerical values descriptors, which do impossible search coincidences. Detector Harris [2], SIFT [3] and SURF [4] are among the most popular and widely used detectors and descriptors signs. Also Maybe decide problem compliance, using epipolar geometry [1, 5]. Epipolar line Maybe be easily calculated at provided What known internal options cameras With relative position And orientation couples cameras So way, Can narrow down region search before one epipolar lines For couples images or even before points intersections two epipolar lines For triplet images. An approach, founded on epipolar geometry, Not presents special requirements To conditions lighting image content; however For this necessary know options cameras And their relative position. Fraser V article "Innovation V automation For metrological systems vision" describes various approaches to finding point correspondence based on epipolar geometry V 2- And 3-dimensional space. He Also claims What computing difficulties fast grow, When increases quantity images.

Group special photogrammetric systems uses reflective goals For definitions key points measured object And flash, to ensure that these purposes are easily distinguishable in an industrial environment, which often has insufficient lighting conditions. This directional light radically changes the structure shadows in the image, cheating like this way descriptor values objects. In that In this case, the point matching problem can only be solved using the epipolar geometry. TO unfortunately,

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on practice dot Maybe A little lie outside calculated epipolar line due to some degree of uncertainty in the estimated relative position cameras or because of imperfections in camera manufacturing.

So way, V real applications better search point V some δ- vicinity of the epipolar line. Moreover, as the number of images increases and goals, area search can contain more than others points or artifacts such as glare or reflections incorrectly recognized by the system as retroreflective targets, therefore the compliance problem becomes non-trivial. Industrial photogrammetric system that uses retroreflective targets [6, 7], therefore must use epipolar geometry to solve the correspondence problem points. System must work on laptop average level. More Togo, because of specifications all process three-dimensional reconstruction from downloads images With cameras It should take no more than 5-6 minutes to obtain accurate three-dimensional coordinates of targets. This requires development some new effective algorithms comparisons points on basis epipolar geometry, which allowed would decide problem V acceptable time.

To achieve this goal, parallelization is used along with iterative circuitry that adjusts the accuracy to estimate targets and camera positions. This allows use heuristic click search algorithms, in particular, which ultimately in the end lead To accurate decision Problems compliance points V acceptable time. Impossible parallelize all problem three-dimensional reconstruction because of her specifics.

However Can much increase general efficiency process, performing parallel processing of data in several stages, thanks to the widespread parallel architecture.

Point matching is one of the key tasks in computer vision. Majority works based on availability photometrically excellent signs, which allow compute a descriptor from image data [8, 9]. SIFT[3] and SURF[4] are one from the most popular And wide used methods. Exist Also work, V which is being considered hybrid approach [8]. However because of use photometrically identical targets should rely solely on epipolar geometry.

Epipolar geometry parallel algorithm

Exists two main approach To finding point matches: With using epipolar geometry and epipolar corridors _

Each three-dimensional point X has its own epipolar plane, which passes through basic line And through X (A Means, And through XL). Intersection epipolar plane With right plane Images forms epipolar line passing through XR. Considering happening, When real three-dimensional X coordinates are unknown, for example , when processing recruitment images, When at us There is only two-dimensional coordinates XL, Can definitely define location XR on right image because of losses depths at projection indicate on plane Images.

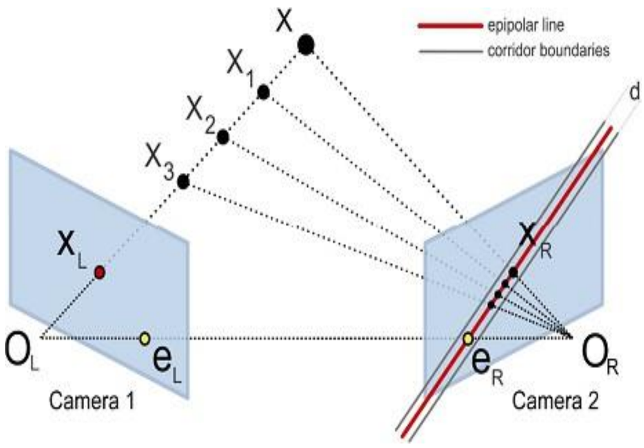

Fig.1. Epipolar geometry And epipolar corridor.

Epipolar line (V form 0), which corresponds XL on right image, May be described How:

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$$e = F * X_L, (1)$$

where e is the vector of the column of coefficients a, b and c ; X_L-column of homogeneous coordinates of points on the left image; -fundamental matrix calculated for pairs of images internal parameters cameras TO .

Relative posture and orientation cameras, which are presented necessary matrix E are calculated:

$$F = K^{-1} * E * K, (2)$$

Obviously, What epipolar line on right image Maybe pass through some different points Images, What does problem compliance points non-trivial. To use epipolar geometry, camera poses and orientations must be known before execution calculations. IN photogrammetric system used So called *coded goals* , which provide global system coordinates For everyone images [6]. TO unfortunately, real cameras Not So perfect as their mathematical models. In the right image, the dot may be slightly deviate from the calculated epipolar line due to some degree of uncertainty in evaluative relative position cameras or because of imperfections making the camera. Thus, in practice it is better to use *an epipolar corridor* of width d . which with more probability will contain point. Switching from epipolar lines on epipolar corridors leads To to that What V region search compliance hits more more neighboring points Images candidate. Except Togo, some images may contain additional artifacts within the corridor such as glare or reflections incorrectly recognized by the system as retroreflective targets. From this It follows that the point matching algorithm must be stable and insensitive to various interference and artifacts.

That's why parallel algorithm Matlab search spot compliance consists of from two stages. On first stage are being built local graphics For everyone points Images parallel. The algorithm also tries to find the maximum clique in each constructed local graph. After completion parallel stage TBC resultant algorithm, to get rid of intersections.

```
parallel_for_each (point ∈ 2DPoints)
  G_p := Ø
  for_each neighbour ∈ point.Targets
    G_p ← vertex(neighbour)
    G_p← edge(point ↔ neighbour)
  end_for_each
  for_each (neighbour ∈ point.Targets)
    for_each (link ∈neighbour.Targets)
      if (G_p ∌ link as vertex)
        G_p← edge(link ↔ neighbour)
      endif
    end_for_each
  end_for_each
  grouped_point := find_maximum_clique_of_min_weight(G_p)
  if (size(grouped_point) ≥ t )
    { cliques } ← grouped_point
  endif
end_parallel_for_each
cliques := sort_by_size (cliques)
foreach clique ∈ cliques
  foreach clique2 ∈cliques[clique...end]
    if (clique ∩ clique2 ≠ Ø)
      cliques := cliques \ clique2
    endif
  end_for_each
end_for_each
```

Fig.2. New algorithm V pseudocode.

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Procedure find_maximum_clique_of_min_weight looking for maximum clique V Gp , choosing that, which It has less total weight the edges V case comparisons two clicks of the same size. From a practical point of view, the clique with the lower total weight ribs It has their peaks, located closer To relevant epipolar lines, What is more preferable By comparison With clique With big total weight ribs .

To implement the algorithm of epipolar corridors to the graph and point matching Used Matlab and C++ Compiler to generate the code. In the current software version algorithm implementations are used by Microsoft C++ Concurrency Runtime \ Parallel Patterns Library For parallelization. Choice based on requirements To being developed photogrammetric software: it must run under MS Windows on a mid-range laptop. Current software only uses the kernel processor to perform calculations.

Conclusion

This article describes how epipolar geometry can be used to search point correspondences, When other methods, such How detectors signs, Not applicable. A multipartition graph is introduced as a mathematical representation of the system and describes how to construct it from epipolar geometry. A parallel implementation of the graphing algorithm and evaluation of its effectiveness in comparison with consistent implementation. Created new algorithm parallel graph For finding spot compliance, which based on idea local graphs small size. Tests prove that the new algorithm is faster than others algorithms for sequential point matching, both on synthetic data and in as part of a photogrammetric system. Moreover, it is accurate and gives specific results for everyone rare cases.

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