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Ramer–Douglas–Peucker algorithm

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The **Ramer–Douglas–Peucker algorithm** (RDP) is an algorithm for reducing the number of points in a curve that is approximated by a series of points. The initial form of the algorithm was independently suggested in 1972 by Urs Ramer and 1973 by David Douglas and Thomas Peucker[1] and several others in the following decade.[2] This algorithm is also known under the names **Douglas–Peucker algorithm**, **iterative end-point fit algorithm** and **split-and-merge algorithm**.

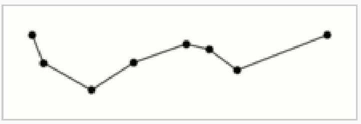
Contents [hide]

Idea [edit]

The purpose of the algorithm is, given a curve composed of line segments, to find a similar curve with fewer points. The algorithm defines 'dissimilar' based on the maximum distance between the original curve and the simplified curve (i.e., the Hausdorff distance between the curves). The simplified curve consists of a subset of the points that defined the original curve.

Algorithm [edit]

The starting curve is an ordered set of points or lines and the distance dimension $\varepsilon > 0$.


Simplifying a piecewise linear curve with the Douglas–Peucker algorithm.

The algorithm recursively divides the line. Initially it is given all the points between the first and last point. It automatically marks the first and last point to be kept. It then finds the point that is furthest from the line segment with the first and last points as end points (this point is obviously furthest on the curve from the approximating line segment between the end points). If the point is closer than ε to the line segment then any points not currently marked to be kept can be discarded without the simplified curve being worse than ε.

If the point furthest from the line segment is greater than ε from the approximation then that point must be kept. The algorithm recursively calls itself with the first point and the worst point and then with the worst point and the last point (which includes marking the worst point being marked as kept).

When the recursion is completed a new output curve can be generated consisting of all (and only) those points that have been marked as kept.

Non-parametric Ramer-Douglas-Peucker [edit]

The choice of ε is usually user-defined. Like most line fitting / polygonal approximation / dominant point detection methods, it can be made non-parametric by using the error bound due to digitization / quantization as a termination condition.[3] MATLAB code for such a non-parametric RDP algorithm[4] is available here.[5]

Pseudocode [edit]

(Assumes the input is a one-based array)

```
function DouglasPeucker(PointList[], epsilon)
```

```
    // Find the point with the maximum distance
    dmax = 0
    index = 0
    end = length(PointList)
    for i = 2 to ( end - 1) {
        d = shortestDistanceToSegment(PointList[i], Line(PointList[1],
PointList[end]))
        if ( d > dmax ) {
            index = i
            dmax = d
        }
    }
    // If max distance is greater than epsilon, recursively simplify
    if ( dmax > epsilon ) {
        // Recursive call
        recResults1[] = DouglasPeucker(PointList[1...index], epsilon)
        recResults2[] = DouglasPeucker(PointList[index...end], epsilon)

        // Build the result list
        ResultList[] = {recResults1[1...length(recResults1)-1],
recResults2[1...length(recResults2)]}
    } else {
        ResultList[] = {PointList[1], PointList[end]}
    }
    // Return the result
    return ResultList[]
end
```

Application [edit]

The algorithm is used for the processing of vector graphics and cartographic generalization.

The algorithm is widely used in robotics[6] to perform simplification and denoising of range data acquired by a rotating range scanner; in this field it is known as the split-and-merge algorithm and is attributed to Duda and Hart.

Complexity [edit]

The expected complexity of this algorithm can be described by the linear recurrence $T(n) = 2T(\frac{n}{2}) + O(n)$, which has the well-known solution (via the master theorem) of $T(n) \in \Theta(n \log n)$. However, the worst-case complexity is $\Theta(n^2)$.

Other line simplification algorithms [edit]

Alternative algorithms for line simplification include:

- Visvalingam–Whyatt
- Reumann–Witkam
- Opheim simplification
- Lang simplification
- Zhao-Saalfeld

References [edit]

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- John Hershberger & Jack Snoeyink, "Speeding Up the Douglas–Peucker Line-Simplification Algorithm", Proc 5th Symp on Data Handling, 134–143 (1992). UBC Tech Report TR-92-07 available at http://www.cs.ubc.ca/cgi-bin/tr/1992/TR-92-07
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- Visvalingam, M., and Whyatt, J.D. "Line Generalisation by Repeated Elimination of the Smallest Area". (1992) CISRG Discussion Paper Series No 10, University of Hull, 16 pp

(http://www2.dcs.hull.ac.uk/CISRG/publications/DPs/DP10/DP10.html)

Notes [edit]

1. ^ See the References for more details
2. ^ Heckbert, Paul S.; Garland, Michael (1997). "Survey of polygonal simplification algorithms" (PDF). p. 4.
3. ^ Prasad, Dilip K.; Leung, Maylor K.H.; Quek, Chai; Cho, Siu-Yeung (2012). "A novel framework for making dominant point detection methods non-parametric". *Image and Vision Computing* **30** (11): 843–859. doi:10.1016/j.imavis.2012.06.010.
4. ^ Prasad, Dilip K.; Quek, Chai; Leung, Maylor K.H.; Cho, Siu-Yeung (2011). *A parameter independent line fitting method*. 1st IAPR Asian Conference on Pattern Recognition (ACPR 2011), Beijing, China, 28-30 Nov. doi:10.1109/ACPR.2011.6166585.
5. ^ Prasad, Dilip K. "Matlab source code for non-parametric RDP". Retrieved 15 October 2013.
6. ^ Nguyen, Viet; Gächter, Stefan; Martinelli, Agostino; Tomatis, Nicola; Siegwart, Roland (2007). "A comparison of line extraction algorithms using 2D range data for indoor mobile robotics" (PDF). *Autonomous Robots* **23** (2): 97. doi:10.1007/s10514-007-9034-y.

External links [edit]

- Implementation of Ramer–Douglas–Peucker and many other simplification algorithms with open source licence in C++
- XSLT implementation of the algorithm for use with KML data.
- You can see the algorithm applied to a GPS log from a bike ride at the bottom of this page
- Interactive visualization of the algorithm
- Implementation in F#
- Ruby gem implementation

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