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Survey on Road Extraction From High Resolution Satellite Images

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Abstract—This paper presents a survey on different algorithms for road extraction from high resolution satellite images behaviour of roads in Ribbon Snakes, Genetic Algorithm, Extended Kalman Filtering based on edge extraction. It has only few parameters to be adjusted. The Support Vector Machine is used to trained extraction of urban and sub urban areas. The Genetic Algorithm allows for a bridging of shadows and partially occluded areas using heavily disturbed evidence in the image. The road network represents the curve segment to be extracted from the image using a curve linear structure detector, which are accurately detected by curve segment. Extended Kalman Filter combined with a special Particle Filter, the EKF traces to a road until a stopping criterion is met. Then instead of terminating process, they have been continued with the process.

Keywords—Ribbon Snakes, Genetic Algorithm, Extended Kalman Filtering (EKF), Particle Filtering (PF), Synthetic Aperture Radar (SAR), Road Detection, Remote Sensing.

I. INTRODUCTION

To extract roads or buildings in topographic objects for GIS (Geographic information system). The major important applications are car navigation or guidance system for police, fire service or forwarding agencies.

The application interacts between the humans which lead to semi automatic system. The approaches relying strongly interact to the road tracking starting from the given points and given extraction after extracting parallel edges in resolution images, as well as updating the existing road maps using satellite images. This has vast images using many applications. The Bayesian estimation techniques uses to road tracking algorithm based on probabilistic model. It consists of two stages: prediction stage and update stage. The Extended Kalman Filter (EKF) one of the method for this class. Particle Filter (PF) is used for nonlinear filtering. The PF algorithm traces to a single road path initiated by given road at beginning of seed points on the road. The road extraction method works for limited processing area on the image. PF combined with EKF to trace the various connected road path, avoid to the obstacles using various condition. The EKF component responds to the road it comes to serve an obstacle. Then PF algorithm controls and regains tracking of the road.

Extracting linear feature, including roads, railroads, and rivers from satellite images using many application, especially area of remote sensing task in order to detect the roads in space borne SAR images as curvilinear structure. We can detect road accurately by grouping method based on a genetic algorithm. The Genetic Algorithm reduce the computational cost.

II. RIBBON SNAKE

The original snakes introduced in M.Kass [1] are curves with parametric representation whose position is optimized under a number of constraints. On the one hand the photometric constraints evoke the image forces which “pull” the snake to features in the image. On the other hand, the geometric constraints give rise to the internal forces which control the shape of the snake ensuring its piecewise smoothness. During optimization the snake evolves from its initial position to a position where the forces compensate each other and the energy of the snake is minimized. This state implies that the snake is located at the image features which best of all satisfy the desired properties.

For road extraction the original snakes are extended with a width component P.Fua[2] leading to a ribbon snake defined as:

$$v(s,t) = (x(s,t), y(s,t), w(s,t)), \quad (0 \leq s \leq 1), \qquad (1)$$

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Where s is proportional to the ribbon's length, t is the current time, x and y is the coordinates of the ribbon's centreline, and w is the ribbon's half width. As shown in figure 1(a) the centre line (x(s,t),y(s,t)) and its width w(s,t) define the sides of the ribbon $v_L(s,t)$ and $v_R(s,t)$. Using this representation, the original expression for the snake's internal energy still holds and the width is constrained by the same "tension" and "rigidity" forces as the two coordinate components. Differently from snakes, the image forces for ribbon snakes are considered along the sides. When optimizing a ribbon to a bright road on a dark background the image function P can be redefined as the sum of the magnitudes of the image gradient along the curves $v_L(s,t)$ and $v_R(s,t)$. an even better way is to use the

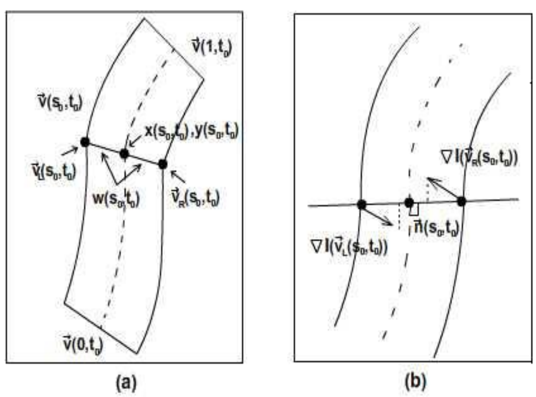

Fig. 1. (a) Parametric representation of the ribbon snake. Each slice of the ribbon $v(s_0,t_0)$ is characterized by its centre $(x(s_0,t_0), y(s_0,t_0))$ and width $w(s_0; t_0)$. Centre and width define points $v_L(s_0, t_0)$ and $v_R(s0; t0)$ corresponding to the left and right side of the ribbon. (b) Image gradients for the left and the right side and their projection to the ribbon's unit normal vector $n(s_0,t_0)$.

Projections of the image gradient onto the ribbon's normal n(s,t) constraining them to be positive at the ribbon's left side and negative at its right side (cf. Figure 1(b)). By this means the correspondence between the road sides and the sides of the ribbon is obtained.

$$P(v(s,t)) = (\Delta I\ (v_L(s,t)) - \Delta I\ (v_R(s,t))).n(s,t) \qquad (2)$$

Using the above for the image function, the expression for the total energy of the ribbon snakes remains identical with the correspondent formula for the energy of the original snake:

$$E(v) = -\int_0^1 P(v(s,t))ds + \frac{1}{2}\int_0^1 \alpha(s)\left|\frac{\partial v(s,t)}{\partial v}\right|2 \quad +\beta(s)\left|\frac{\partial 2v(s,t)}{\partial s2}\right|ds \qquad (3)$$

The first term of equation (3) represents the image energy and the second corresponds to the internal energy. α(s) and β(s) are arbitrary functions which determine the influence of the geometric constraints on the optimization.

The application of the ribbon snakes to fully-automatic extraction requires that the balance between their image and internal energies has to be achieved automatically. Assuming the initial estimate of the ribbon to be close to the final solution, this can be enforced by substituting the functions α(s) and β(s) in (3) with a factor λ P.Fua[2]:

$$\lambda = \frac{|\delta Eimg\ (v)|}{|\delta Eint\ (v)|}, \qquad (4)$$

Where δ is the variational operator. This implication avoids the manual adjustment of α(s) and β(s). What is also important for the extraction is the ability to restrict and control the ribbon's motion during optimization. For this reason it is a good idea to "embed" the ribbon in a viscous medium and obtain the solution by minimizing the term$\int E(v) + D(v)dt$, where D is the dissipation functional D(v)=1/2 $\int \gamma(s)|Vt|2ds$ with damping coefficient γ. As shown in P.Fua[2] the derivation of γ form

$$\gamma = \frac{\sqrt{2n}}{\Delta}\left|\frac{\partial E(v)}{\partial v}\right| \qquad (5)$$

Ensures that the displacement of each vertex of the ribbon during one optimization step is on average of magnitude Δ. This property has shown to be very useful for automatic road extraction since changing the Δ, the search space for the hypothetical road sides can be directly controlled by a higher level program.

II. GENETIC ALGORITHM

The GA is a method of searching a solution for an engineering theme by imitating evolutionary rules of life D.E. Goldberg. The procedure used at each stage of region growing is presented in Fig. 4.

I. Definition of a Chromosome:

As shown in Fig. 5, we design the chromosome of an individual whose length is the same as the total number of segments in the search region. Each bit of the chromosome corresponds to each segment in the image and is initialized by a randomly selected 0 or 1. The probability that 1s are allocated to bits is adaptively changed according to the number of segments in the search region. That is, if there are many segments in that region the probability is set low and, if there are few, the probability is set high. When we calculate the fitness of the chromosome during the evolutionary process, the segments with 1s are only

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considered, and the population size Np, which is the number of individuals, is set to 100 in our experiment.

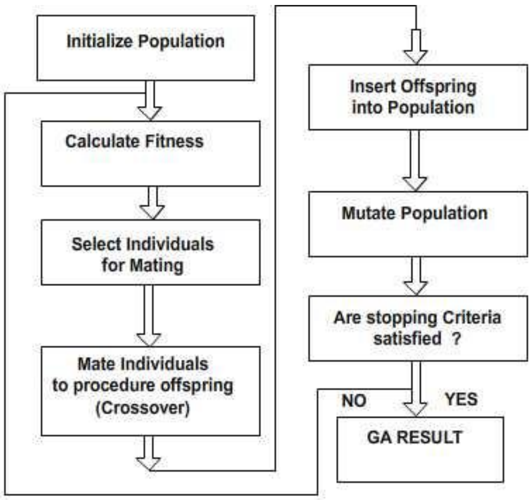
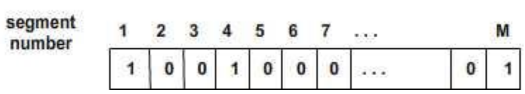


Fig. 2. Procedure of the GA.



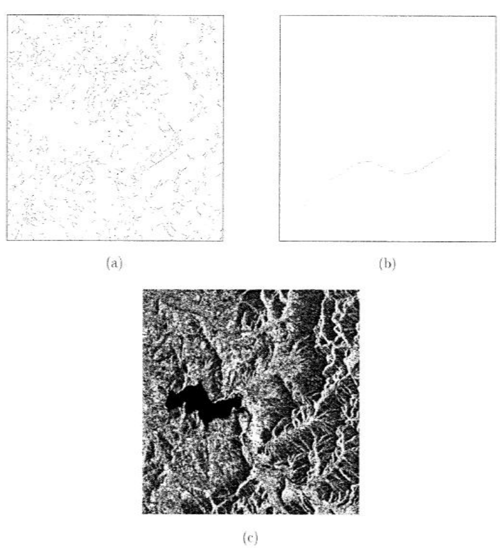


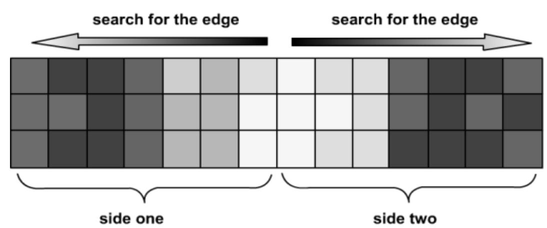
Fig.3.Experimental results.(a)Extracted curvilinear structures (see Fig. 2), (b) grouped segments by region-growing-based GA, and (c) detected road overlaid on the sigma-filtered image of Fig. 2(a).

IV. ROAD TRACKING ALGORITHM

The road-tracking algorithm consists of two main modules: the EKF module and the PF module. These two modules alternately replace the method to each other, as explained in the following two sections. Fig. 4 shows the overall procedure of the road-tracking algorithm.

1) EKF Module

This module is initialized with a seed point given at the start of the road-tracking process. The starting point should include coordinates of the road centre, road direction, and a common estimation of the road width at that point. The road centre coordinates and the road direction are considered as the initial state of the system, namely,x1



searching for road edges in two parts of the window.

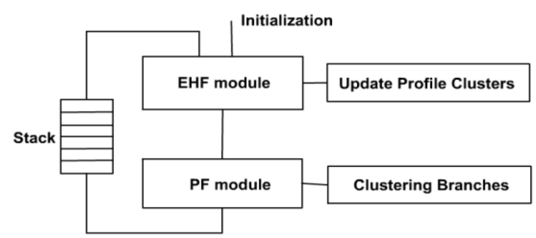


Fig. 4. Road Tracking Algorithm

(the fourth element of x1 is assumed to be zero). This starting point is also used to initialize the profile cluster. The EKF module starts tracing the road using the initial state and the initial profile cluster. While progressing along the road path, the profile clusters are updated, and new appropriate clusters are added as road intensities and/or widths change.

When the EKF module faces a severe obstacle on the road Path or arrives at a road junction, the update profile cluster procedure cannot successfully create new profile clusters. This is due to the fact that the profiles extracted at road junctions or obstacles cannot pass validation tests or survive the authentication process after a pre assigned number of steps since their creation. Therefore, the moving average of the profile error will increase and exceed a predefined threshold. This threshold determines where the EKF module should stop. This threshold can affect the overall outcome of the road detection algorithm. If it is set to a very low value, the EKF module will stop too often at each

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small obstacle or noise on the road path. On the other hand, a very high threshold value will cause the EKF algorithm to proceed into a wrong off-road area or pass over a junction without finding road branches. Initialize the PF module, the EKF module transfers the information about its last successful step of the present road segment onto the PF module.

V. Conclusion

This paper illustrates the road extraction from high resolution satellite images with its behaviour. It follows major algorithms as Ribbon, Genetic and Extended Kalman Filters where these algorithms face drawback of partially locating the areas. This also cannot predict the actual location of road extractions from satellites. The support vector machine used to train the sample images.

Future work concentrates on exploiting the location of areas more clearly by adopting certain mechanisms that support of high resolution view of images that gains more advantage on accuracy and performance.

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