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Quadrangulations on 3-colored point sets with Steiner points

Content :

Let P be a point set on the plane, and consider whether P is {¥em quadrangulatable¥/}, that is, whether there exists a 2-connected bipartite plane graph G with edge edge straight segment such that $V(G)=P$, that the outer cycle of G coincides with Conv(P), that each finite face of G is quadrilateral. It is easy to see that it is possible if an even number of points of P lie on Conv(P). Hence we give a k-coloring of P and consider the same problem, avoiding edges joining two vertices of P with the same color. In this case, we always assume that the number of the points of P lying on Conv(P) is even and any two consecutive points on Conv(P) have distinct colors. However, there is a 2-colored non-quadrangulatable point set P. So we introduce a {¥em Steiner point}, which can be put in any position of the interior of Conv(P) and may be colored by any color of the k colors. When $k=2$, Alverez et al. proved that if a point set P on the plane consists of $¥frac n2$ red and $¥frac n2$ blue points in general position, then adding Steiner points Q with $|Q| ¥leq ¥lfloor ¥frac {n-2}6 ¥rfloor +
¥lfloor ¥frac n4 ¥rfloor +1$,
$P ¥cup Q$ is quadrangulatable, but there exists a non-quadrangulatable 3-colored point set for which no matter how many Steiner points are added. In this paper, we define the winding number for a 3-colored point set P, and prove that a 3-colored point set P in general position with a finite number of Steiner points Q added is quadrangulatable if and only if the winding number of P is zero. When $P ¥cup Q$ is quadrangulatable, we prove $|Q| ¥leq ¥frac {7n+34m-48}{18}$, where $|P|=n$ and the number of points of P in Conv(P) is $2m$.

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