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Chains of Dot Products over Finite Point Sets in $\mathbb{R}^2$

Given a finite point set $\Lambda \subset \mathbb{R}^2$, we examine the behavior of successive dot products between sequences of distinct points. Fix $k \in \mathbb{N}$. Now, let $\{\alpha_i\}_{i=1}^{k}$ be a sequence of numbers, $0 < \alpha_i < 1$, and let $\{R_i\}_{i=1}^{k+1}$ be a sequence of points such that $R_i \cdot R_{i+1} = \alpha_i$ for each $1 \leq i \leq k+1$. Then, together, we call the sequences $\{\alpha_i\}_{i=1}^{k}$, $\{R_i\}_{i=1}^{k+1}$ a *k-chain*. Now, given that $\#\Lambda = N$, we prove that, for fixed k, the maximum number of k-chains that can exist over Λ is $N^{\frac{4}{3}(\lceil \frac{k+1}{2} \rceil)}$. We also construct a point-set which sharpens this bound in $\mathbb{R}^2$. Finally, we explore extensions of this result, and its motivations in questions of Euclidean distances originally proposed by Paul Erdős.