

# Nyström based Kernel SVM

- Solving the dual form of kernel SVM:

$$\max_{\alpha \in \mathbb{R}^n} - \frac{1}{n} \sum_{i=1}^n \ell_i^*(\alpha_i) - \frac{1}{2\lambda n^2} \alpha^T K \alpha$$

- Using Nyström method to approximate large kernel matrix  $K$  as:

The diagram illustrates the Nyström method for approximating a large kernel matrix  $K$ . On the left, the matrix  $K$  is shown as a 2x2 block matrix:  $\begin{bmatrix} K_m & S^T \\ S & B \end{bmatrix}$ , where  $K_m$  is an orange square,  $S^T$  is a blue rectangle,  $S$  is a blue rectangle, and  $B$  is a yellow square. This is followed by an approximation symbol  $\approx$ . To the right, the approximation is shown as a product of three matrices:  $\begin{bmatrix} K_m \\ S \end{bmatrix} \times K_m^\dagger \times \begin{bmatrix} K_m & S^T \end{bmatrix}$ . The first matrix is a vertical stack of an orange square  $K_m$  and a blue rectangle  $S$ . The second matrix is a small orange square  $K_m^\dagger$ . The third matrix is a horizontal stack of an orange square  $K_m$  and a blue rectangle  $S^T$ .

- The two-step approach:
  - Adding  $\ell_1$  term to learn a good dual solution

$$\max_{\alpha \in \mathbb{R}^n} -\frac{1}{n} \sum_{i=1}^n \ell_i^*(\alpha_i) - \frac{1}{2\lambda n^2} \alpha^T \hat{K} \alpha - \frac{\tau}{n} \|\alpha\|_1$$

- Constructing a new set of landmark points based on good dual solution for Nyström approximation and retraining SVM
- Establishing a theoretical guarantee on the learned dual solution.
- Experimental results show that the proposed two-step approach improves the performance.

Welcome to check the detail about our paper!