
Algorithm 1 QPSO-RF Algorithm

Input: a data set \mathbf{S} , a feature set \mathbf{F} , pre-fixed parameters including number of particles p , dimension of the particles d , maximum iteration number max_{iter} , and random forest \mathbf{H} as a learning algorithm. Objective function is

$$\operatorname{argmax}_{\mathbf{F}_1} \min(\text{sensitivity}, \text{specificity})$$

where \mathbf{F}_1 is a potential feature subset, sensitivity and specificity are classification metrics on the test set returned by the learning algorithm built on \mathbf{F}_1 .

Output: a feature subset \mathbf{F}_1 that gives the best fitness value.

Resampling use SMOTE algorithm to resample the training set.

Initialization of QPSO: randomize binary bits for particles, particles' personal best $pbest$ and swarm's global best $gbest$.

- 1: **for** $iter \leq max_{iter}$: **do**
- 2: **for** $i \leq p$: **do**
- 3: Perform mutation operation on each particle.
- 4: Determine the mean best (mbest) for each particle at dimension d :

$$m_d^{best} = \begin{cases} 1, & \frac{1}{p} \sum_i x_{i,d}^{pbest} > 0.5 \\ 0, & \frac{1}{p} \sum_i x_{i,d}^{pbest} < 0.5 \\ 1 \text{ with prob} = \frac{1}{2}, & \frac{1}{p} \sum_i x_{i,d}^{pbest} = 0.5 \end{cases}$$

- 5: Select one of the offspring randomly.
- 6: For each dimension, flip the particle with mutation probability defined as

$$\min\left(\frac{\beta \times d_H(x_i, x^{mbest}) \times \ln \frac{1}{u}}{p}, 1\right)$$

where d_H is the counts of bits different in the two strings, $u \sim \text{unif}(0,1)$ and β is a tuning parameter set to decrease from 1.4 to 0.4 over the iterations.

- 7: On resampled training set, evaluate each particle using \mathbf{H} built on the selected features (positions that has value 1s) and compare particle objective values; update $pbest$ as the best feature subset one particle visited so far and $gbest$ as the best feature subset of the swarm visited so far.
 - 8: **end for**
 - 9: **end for**
 - 10: **return** $gbest$ vector that represent the best feature subset.
-