CArBO: Cost Apportioned BO

1. CArBO

- **EI**
- **EIpc**

CArBO

1.
2.
3. 40%

- OK
- 100 1
-
-

2. CArBO 2

1 0-12.5%

-
-
- 4 →15

2 12.5-100%

- EI-cooling α 1.0→0.0

- EIpc
- EI

```
flowchart LR
    Init["        <br/>  : 0-12.5%<br/>      <br/>      <br/>

    Early["     <br/>  : 12.5-40%<br/>α ≈ 1.0<br/>EIpc   <br/>     "]

    Middle["     <br/>  : 40-70%<br/>α ≈ 0.5<br/>     <br/>       "]

    Late["     <br/>  : 70-100%<br/>α ≈ 0.0<br/>EI   <br/>     "]

    Init -->|Algorithm 1| Early
    Early -->|EI-cooling| Middle
    Middle -->|EI-cooling| Late

    style Init fill:#bbdefb,stroke:#1976d2,stroke-width:3px
    style Early fill:#ffe0b2,stroke:#f57c00,stroke-width:3px
    style Middle fill:#e1bee7,stroke:#7b1fa2,stroke-width:3px
    style Late fill:#ffcdd2,stroke:#c62828,stroke-width:3px
```

2. Algorithm 1

-
-

Algorithm 1

```
flowchart TB
    Start([  ])
    Start --> Init["`**   **
         = τinit     1/8
```

```
      = 0
      = [ ]`"]

    Init --> MainLoop{      <      }

    MainLoop -->|  | Step1[100       ]
    MainLoop -->|   | End([  ])

    Step1 --> Step2[99        ]

    Step2 --> Reduction["`**      99      **

        1
         1   `"]

    Reduction --> Step3[   1    <br/>        ]

    Step3 --> Step4[   1       <br/>            ]

    Step4 --> Step5[            ]

    Step5 --> MainLoop

    style Start fill:#e8f5e9,stroke:#2e7d32,stroke-width:3px
    style End fill:#ffebee,stroke:#c62828,stroke-width:3px
    style MainLoop fill:#e1f5fe,stroke:#0277bd,stroke-width:3px
    style Step4 fill:#fce4ec,stroke:#c2185b,stroke-width:3px
    style Reduction fill:#fff9c4,stroke:#f57f17,stroke-width:2px
```

- GP   100
-
-          1-2

-
-

- learning_rate=0.01, layers=3
-
- **100** → → → 1

3. EI-cooling

$$ \text{EI-cool}(x) = \frac{\text{EI}(x)}{c(x)^{\alpha}} $$

$$ \alpha = \frac{\tau - \tau_k}{\tau - \tau_{\text{init}}} $$

- τ - τ_k - τ_{init} - α 1.0 → 0.0

- **α ≈ 1.0** EIpc
- **α ≈ 0.5**
- **α ≈ 0.0** EI

4. Algorithm 2

```
flowchart TB
    Start([  ])
    Start --> Init[   <br/>    1/8        ]

    Init --> Phase1{        }

    Phase1 -->|  | InitDesign["`**Algorithm 1   **
        1       `"]
```

```
    InitDesign --> UpdatePhase1[     <br/>    ]

    UpdatePhase1 --> Phase1

    Phase1 -->|   | BuildModel["`**GP     **

          `"]

    BuildModel --> Phase2{     }

    Phase2 -->|  | CalcAlpha["`**α    **

    1.0    → 0.0    `"]

    CalcAlpha --> SelectNext["`**        **
    EI-cooling
                `"]

    SelectNext --> EvaluatePoint["`**    **

            `"]

    EvaluatePoint --> UpdatePhase2["`**     **
    GP
         `"]

    UpdatePhase2 --> Phase2

    Phase2 -->|   | ReturnBest[       ]

    ReturnBest --> End([  ])

    style Start fill:#e8f5e9,stroke:#2e7d32,stroke-width:3px
    style End fill:#ffebee,stroke:#c62828,stroke-width:3px
    style Phase1 fill:#e3f2fd,stroke:#1565c0,stroke-width:3px
    style Phase2 fill:#fff3e0,stroke:#ef6c00,stroke-width:3px
```

```
    style EvaluatePoint fill:#fce4ec,stroke:#c2185b,stroke-width:3px
    style CalcAlpha fill:#f3e5f5,stroke:#7b1fa2,stroke-width:2px
```