Elastic Neural Net
for standalone RICH ring finding

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Traveling Salesman Problem

\[ E(s_{ia}, \bar{y}_{a}) = \sum_{ia} s_{ia} \cdot |\bar{x}_{i} - \bar{y}_{a}|^2 + \gamma \cdot \sum_{a} |\bar{y}_{a} - \bar{y}_{a+1}|^2 \]

\[ \Delta \bar{y}_{a} = \eta \left[ 2 \sum_{i} \nu_{ia} \cdot (\bar{x}_{i} - \bar{y}_{a}) + \gamma \cdot (\bar{y}_{a+1} - 2\bar{y}_{a} + \bar{y}_{a-1}) \right] \]

### Discrete EN

<table>
<thead>
<tr>
<th>File name</th>
<th>Number of cities</th>
<th>Extra path (%)</th>
<th>Time, ms</th>
<th>Time per city, ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>berlin52</td>
<td>52</td>
<td>0.00</td>
<td>0.98</td>
<td>19</td>
</tr>
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<td>st70</td>
<td>70</td>
<td>4.27</td>
<td>1.27</td>
<td>18</td>
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<td>kroA100</td>
<td>100</td>
<td>3.03</td>
<td>1.46</td>
<td>15</td>
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<td>lin105</td>
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<td>0.78</td>
<td>1.84</td>
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<td>8.37</td>
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<td>25</td>
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<td>pr2392</td>
<td>2392</td>
<td>8.42</td>
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<td>24</td>
</tr>
</tbody>
</table>

(*) Pentium IV/2.4 GHz

Features:

- External forces - minimizing distances
- Internal forces - constraint on Fourier coefficients
**Scheme:**

- Loop over hits
- Finding a ring in a local area around the hit
- Sorting of the found rings

**Details:**

- No internal forces - fixed ring shape (circle)
- External forces - minimize distances
- Discrete ring evolution - direct finding of the minimum in 2-3 iterations
- Time \( \sim \) total number of hits
**RICH Detector in the CBM Experiment at GSI**

1 central Au+Au collision, 25 AGeV (UrQMD)

- Mirror: R = 450 cm
- Gaseous radiator: 40\% He + 60\% CH\textsubscript{4}N\textsubscript{2}
- Beam
- 3.3 m
- 4.7 m
- 2 m

- 38 rings/event
- 33 electrons
- 5 pions
- 12.6 e from primary vertex
- 5 pions from primary vertex
**EN – Performance**

All set: $N$ hits $\geq 5$
Ref set: $N$ hits $\geq 15$
Extra set: $5 \leq N$ hits $< 15$
Reconstructed: $\geq 70\%$ hits from the same MC
Clone: MC reconstructed few times
Ghost: $< 70\%$ hits from the same MC

<table>
<thead>
<tr>
<th>Rings set</th>
<th>Performance (%)</th>
<th>Number of rings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference set efficiency</td>
<td>92.21</td>
<td>1425</td>
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<tr>
<td>All set efficiency</td>
<td>80.52</td>
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<td>Extra set efficiency</td>
<td>74.47</td>
<td>2754</td>
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<td>Clone rate</td>
<td>3.26</td>
<td>142</td>
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<td>Ghost rate</td>
<td>14.98</td>
<td>652</td>
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<tr>
<td>Found MC rings/event</td>
<td>33</td>
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<tr>
<td>Time/event (ms)</td>
<td>1.07</td>
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</tbody>
</table>
Conclusion

• **Efficient** ring finder based on the elastic net
• **Standalone** – no track guidance necessary
• **Simple** – suitable for hardware implementation
• **Fast** – can be used for triggering