Adaptive-Partial Template Update with Center-Shifting Recovery for High Frame Rate and Ultra-Low Delay Deformation Matching System

**Background**
- Human-machine interaction
  - Projection mapping
  - Gesture recognition
  - Automatic driving
  - AR clothing system

**Target**
- FPGA implementation of high frame rate and ultra-low delay deformation matching system

**Challenges**
- Ensure ultra-low delay
- Improve robustness to Template-drift & Template-loss

**Proposals**

**Proposal 1: Partial update with new keypoint addition**
- Input pixel flow
- Pixel descriptor
- Template matching
- Matched keypoint addition
- New template descriptor

**Proposal 2: Flexible ROI with hamming threshold descent**
- Matched keypoints
- Boundary points
- Polygonal boundary
- New template ROI
- Inner region -> Higher $h_t$ -> Easier to be matched
- Outer region -> Lower $h_t$ -> Harder to be matched

**Proposal 3: Center-shifting recovery with region check**
- Multiple pixel-wise differences ($d_{pixel}$)
- Previous ROI
- Invalid ROI (lost)
- Recovered ROI

**Evaluation results**
- Matching accuracy
  - Average F-score: 71.01%
  - Solve problems in most cases

**Conclusion**
- Achieve deformation matching system (784fps, 640*480) with ultra-low delay (0.808ms/frame)

**Hardware performance**

<table>
<thead>
<tr>
<th>Resource</th>
<th>Utilization</th>
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<tbody>
<tr>
<td># LUT</td>
<td>101233 (49.67%)</td>
</tr>
<tr>
<td># Flip Flop</td>
<td>112198 (27.53%)</td>
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<tr>
<td># BRAM</td>
<td>28.50 (6.40%)</td>
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<tr>
<td># DSP</td>
<td>36 (4.29%)</td>
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<table>
<thead>
<tr>
<th>Input frame rate</th>
<th>Processing delay</th>
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</thead>
<tbody>
<tr>
<td>784 fps</td>
<td>0.808 ms/frame</td>
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