**Contribution**

We present an active sampling method to speed up conventional pixel-wise background subtraction algorithms. The proposed masking method successfully speeds up approximately 6000% without deteriorating detection performance.

**Research Motivation**

- Imitate the selective attention mechanism of human
  - Empirical attention
  - Intentional attention to moving object appearing region
  - Neglect background or dynamic region
- Most pixels from surveillance video are background region

**Overall Scheme**

- **Passive sampling** → Full search.
  - Conventional background subtraction.
  - Probability of foreground is assumed uniform.
- **Active sampling** → Adaptive and flexible search.
  - Designing sampling strategy is required.

**Active Sampling Strategy**

The sampling mask \( \mathbf{M} \) is obtained by a combination of three masks by a pixel-wise ‘OR’ operation (\( \oplus \)) as

\[
\mathbf{M} = \mathbf{M}_{\text{SEI}} \oplus \mathbf{M}_{\text{SP}} \oplus \mathbf{M}_{\text{RS}}.
\]

The sampling masks are generated based on the foreground probability map \( P_{FG} \) and foreground detected result \( D_{FG} \).

- **Randomly Scattered Sampling** \( M_{RS} \)
  - Uniformly scattered.
  - Random samples are useful to capture unpredictable cases.
- **Surprise Pixel Sampling** \( M_{SP} \)
  - Abnormal foreground is caused by spontaneousness.
  - Random samples are useful to capture unpredictable cases.
- **Active Attentional Sampling** \( M_{SEI} \)
  - Foreground probability map \( P_{FG} \) and foreground detected result \( D_{FG} \), \( D_{SEI} = P_{FG} \oplus D_{FG} \).

**Active Sampling Mask Generation**

- **Randomly Scattered Sampling** \( M_{RS} \)
  - Uniformly scattered.
  - Random samples are useful to capture unpredictable cases.
- **Surprise Pixel Sampling** \( M_{SP} \)
  - Abnormal foreground is caused by spontaneousness.
  - Random samples are useful to capture unpredictable cases.
- **Active Attentional Sampling** \( M_{SEI} \)
  - Foreground probability map \( P_{FG} \) and foreground detected result \( D_{FG} \), \( D_{SEI} = P_{FG} \oplus D_{FG} \).

**ACTIVE ATTENTIONAL SAMPLING FOR SPEED-UP OF BACKGROUND SUBTRACTION**

Hyung Jin Chang, Hawook Jeong and Jin Young Choi

(changhj, hujeong, jychoi)@enu.ac.kr

---

**Overall Scheme**

**Active Attentional Sampling** for Speed-up of Background Subtraction

**Foreground Probability Map Generation**

Using three properties of foreground (\( M_{SEI} \), \( M_{SP} \), and \( M_{RS} \)), the foreground probability for a pixel \( n \) at frame \( t \) is designed as

\[
P_{FG}(n, t) = M_{SEI}(n, t) \times M_{SP}(n, t) \times (1 - M_{RS}(n, t)).
\]

- **Temporal property** \( M_{T} \): A pixel \( n \) is more likely to be a part of the foreground region if it has been a foreground pixel previously.
  \[
  M_{T}(n, t) = 1 - \alpha_{T} M_{T}(n, t-1) + \alpha_{T} D_{T}(n, t).
  \]

- **Spatial property** \( M_{S} \): A pixel \( n \) has a high probability of being a foreground pixel if the surrounding pixels of the foreground have been changed before.
  \[
  M_{S}(n, t) = (1 - \alpha_{S} M_{S}(n, t-1)) + \alpha_{S} D_{S}(n, t).
  \]

- **Frequency property** \( M_{F} \): A pixel \( n \) has a high probability of being a foreground pixel if a foreground/background region has been changed before.
  \[
  M_{F}(n, t) = (1 - \alpha_{F} M_{F}(n, t-1)) + \alpha_{F} D_{F}(n, t).
  \]

**Active Attentional Sampling**

\( M_{SEI}(n, t) \)

- \( P_{FG}(n, t) = 1 \) if \( (M_{SEI}(n, t) \neq 1 \) or \( D_{SEI}(n, t) \neq 0 \)
- 0 otherwise.

**Proposed Method**

- \( V \)

\[
\frac{\text{Time of Original (ms)}}{\text{Time of Proposed (ms)}} = 0.05
\]

**Performance**

- **Implementation**
  - Core 2 Duo E5700 CPU, 2 GB RAM.
- **Efficiency of Active Attentional Sampling**
  - We have monitored sequential intensity changes of two pixels (\( A \) and \( B \)). The proposed sampling catches pixel value changing moment adaptively and accurately with much less samples.

**Detection Performance Comparison**

- The proposed method significantly shortens the detection time (on average 6.6 times).

**Speed-up Performance Comparison**

- The speed-up ratio of our method surpasses the other similar selective sampling-based methods.

**Real-Time Detection in Full HD Video (1920 × 1080)**

- The original GMM also takes more time when the foreground region increases. So the ratio of speed-up is maintained uniformly.

- The speed-up ratio of our method surpasses the other similar selective sampling-based methods.

---

**Active Sampling**

- Sampling mask \( \mathbf{M} \) obtained by combination of three masks by a pixel-wise ‘OR’ operation (\( \oplus \)) as

\[
\mathbf{M} = \mathbf{M}_{\text{SEI}} \oplus \mathbf{M}_{\text{SP}} \oplus \mathbf{M}_{\text{RS}}.
\]

**Active Attentional Sampling**

- Foreground probability map \( P_{FG}(n, t) \) and foreground detected result \( D_{FG}(n, t) \).

\[
P_{FG}(n, t) = M_{SEI}(n, t) \times M_{SP}(n, t) \times (1 - M_{RS}(n, t)).
\]

**Proposed Method**

- Uniformly scattered.
- Random samples are useful to capture unpredictable cases.

**Surprise Pixel Sampling**

- Abnormal foreground is caused by spontaneousness.
- Random samples are useful to capture unpredictable cases.

**Active Attentional Sampling**

- Foreground probability map \( P_{FG}(n, t) \) and foreground detected result \( D_{FG}(n, t) \).

\[
P_{FG}(n, t) = M_{SEI}(n, t) \times M_{SP}(n, t) \times (1 - M_{RS}(n, t)).
\]