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A study on the detection of a pedestrian holding an umbrella with a Selective DPM

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Abstract In recent years, pedestrian detection from an in-vehicle camera has been attracting interest. However, in the case of a raining situation, there is a problem that the detection accuracy decreases because the head of a pedestrian tends to be occluded by an umbrella. In this report, as a variation of the deformable part models (DPM) which is widely used in the field of object recognition, we propose "Selective DPM" which selectively chooses the original part filters and additional part filters trained independently. In the detection of a pedestrian holding an umbrella, the selection of head and umbrella parts will make pedestrian detection more robust to the occlusion. We conducted experiments to evaluate the performance of the proposed method. As a result, pedestrian detection with the Selective DPM achieved high detection accuracy in raining situations, compared with the detection by conventional DPM. Moreover, we confirmed that it does not affect the pedestrian detection accuracy in fine weather.
Key words Pedestrian detection, Rain, DPM, Parts selection

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height) x m Z ' • h Ž € ã w ¶ ± ï Ó ç t S Z " É › q " } ‡ h | ¤ ± ï Ó ç t S M o ã º w Á t h þ › Ñ Ÿ ç » ± ¶ t ¦ V ` | è × w ¢ SVM t ' " Ñ Ÿ ç » w ‹ $F_a$ › ¶ 6 b " } Í " À • " $v_a$ x | U Z 0 Å T ' w Í " À w ì 0 • " $(x,y)$ w É $v_a = (\overline{x}, \overline{y})$ q b " } ! ¯ µ Ä $d_a$ q ` o x | U Z 0 Å T ' w Í " À w ì 0 • " (x,y) w ü „ $_x$, $_y$ › { Š | f w x à S ' | y à M ² w Y F ü Í w u $N(\mu_x, \_x)N(\mu_y, \_y)$ › $d_a \cdot \_d(x)$ w E ~ " t ; M " }

3.2 Í " À ¬ R DPM t ' " ú . U Z

Ü (1) w ' O t | DPM w b , o w Í " À Ñ Ÿ ç » › U Z Ì t – ; ` h Ô ù | U Z 0 Å w ° æ t ¦ « ç " ´ ã ï U C \ b " q | f w æ ü t 0 ` h Í " À Ñ Ÿ ç » w t ‹ U ÿ X s l o ` ‡ O } \ w ' O s ¦ « ç " ´ ã ï w è ¹ › ÿ n ^ d " t x | t w q M Í " À Ñ Ÿ ç » x U Z t b ; d c | t w ' M ‹ w i Z › b ; b " \ q U ® p K " q ß Q ' • " } f \ p Š O p x | DPM t Í " À Ñ Ÿ ç » w ¬ R › æ s O ; Ï › Ë h d " h Š t | Þ Ã ç m › Ž < w ' O t ü Â b " }

$$m_f = \{p_0, p_{f_1}, ..., p_{f_k}\} \quad (6)$$

$$m_s = \{p_{s_1}, ..., p_{s_l}\} \text{ y} \quad (7)$$

\ \ p | m_f x U Z Ì t ž c – ; b " Í " À Ñ Ÿ ç » w B ù p K " | m_s x U Z Ì t ¬ R $ t – ; b " Í " À Ñ Ÿ ç » w B ù p K " } h i ` | Þ Ã ç m w ç " Ä Ñ Ÿ ç » $p_0$ x ž c $m_f$ t ‡ • " ‹ w q b " } ‡ h | k + l = | m | p K " } \ w q V Í " À Ñ Ÿ ç » w ü Â x â " ² U Í å Ý " » q ` o ¦ b " } \ w ü Â ` h Í " À Ñ Ÿ ç » w B ù w O j | $m_s$ t ‡ • " Í " À Ñ Ÿ ç » t 0 ` o ¬ R r g › æ s O ' O | Ü (1) › Ž < w ' O t ! Ë b " }

$$(m, x_0) = (m_f, x_0) + \max_{c \in P(m_s)} (c, x_0) \quad (8)$$

\ \ p |

$$(c, x_0) = \max_{p_i \in c} \{F_i \cdot \_i(x_0 + v_i + \_x) - d_i \cdot \_d(x)\} \quad (9)$$

p K " } h i ` | $P(m_s)$ x m_s w ^ B ù T ' í B ù › † M h B ù p K " | $P(m_s) = \{c : a\ set \mid c \subseteq m_s\}$ Š p K " } « Q y | m_s t ‡ • " Í " À : U 3 p K " q V |

$$P(m_s) = \{\{p_{s_1}\}, \{p_{s_2}\}, \{p_{s_3}\}, \{p_{s_1}, p_{s_2}\}, \{p_{s_1}, p_{s_3}\}, \{p_{s_2}, p_{s_3}\}, \{p_{s_1}, p_{s_2}, p_{s_3}\}\}$$

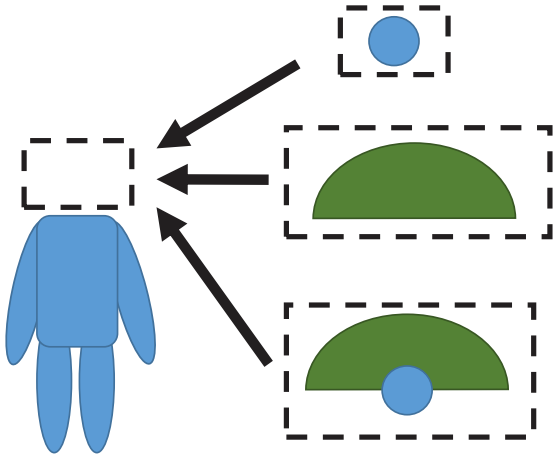
w ' O s Í " À w Ê ^ ù ~ d › ¯ b B ù q s " }

$$\max_{c \in P(m_s)} (c, x_0) \text{ x | } P(m_s) \text{ T ' Ý } \mu \text{ ¯ ž U 7 ‹ ô X s "}$$

Í " À Ñ Ÿ ç » w Ê ^ ù ~ d c › ¬ R b " ò p K " }

3.3 Í " À ¬ R DPM t ' " •) ` 2 æ U Z

Š … p x | ² … t S M o † Ì ` h Í " À ¬ R DPM t ' l o • ) ` 2 æ › U Z b " O t m M o † Ì b " } Ž < p x | Í " À w å C r g S ' | Í " À Ñ Ÿ ç » w ¬ R r g t m M o q t † Ì b " }



$ 4 Í " À ¬ R w 2 æ Þ Ã ç w " æ $

3.3.1 Í " À w å C

Í 1 Ì w × ^ w ø æ ¥ p x | X w 2 æ U • ›) ` o M " h Š | • › U Z Þ Ã ç t Ê ^ ‰ \ q t ' l o 2 æ w U Z ^ S U ² Í p V " q ß Q ' • " } f \ p Š O p x | 2 æ w ^ › ¶ 6 ` h DPM t 0 ` o | • › ¯ q b " Í " À Ñ Ÿ ç » $p_u$ › å C ` | $p_a = p_u$ q ` o 2 æ Þ Ã ç › ¦ Á b " } • Ñ Ÿ ç » › å C ` h Ô ù w 2 æ Þ Ã ç x m = $\{p_0, ..., p_n, p_u\}$ q ¯ q p V " }

3.3.2 Í " À ¬ R

•) ` 2 æ › U Z b " Ô ù | • t ' l o 2 æ w „ æ U Å ^ • " Ý ¯ U ` y ` y C \ b " } ' l o „ æ Ç Ù t " ^ • h Í " À Ñ Ÿ ç » w t U q X s l o ` ‡ O } f \ p •) ` 2 æ w U Z t S M o x | „ æ q • t ì p b " Í " À Ñ Ÿ ç » w ^ › Í " À ¬ R w 0 Å q b " } h i ` | „ æ q • Ž Ž w Í " À x × t – ; b " ‹ w q b " } b s ~ j | „ æ t ì p b " Í " À › p_h q b " q | $m_s = \{p_h, p_u\}$ p K " | $m_f = m$ Š m_s q s " } \ w q V | P = {{ p_h }, { p_u }, { p_h, p_u }} p K " } \ w Í " À ¬ R t ' " 2 æ Þ Ã ç w " æ $ › $ 4 t Ô b } Š O x | \ w ' O s 3 Í » " ï w Í " À w Ê ^ ù ~ d T ' Ý µ ¯ ž U 7 ‹ ô M ‹ w › ¬ R b " O q s " }

4. ° A î g

4.1 î g º 0

Š O w Í 1 Ì w 2 æ U Z t S Z " ® Q › ¬ Ý b " h Š | Í 1 Ì L § Ý å h þ › ; M h 2 æ U Z î g › æ s l h } ‡ h | Š O w V 1 Ì t S Z " 2 æ U Z ^ S › Ð * b " h Š | V 1 Ì w L § Ý å h þ t 0 ` o ‹ ‰ 7 t î g › æ s l h } DPM w î ÷ t x Felzenszwalb ' t ' l o ¬ ‰ ^ • o M " î ÷ [7] › ; M h }

4.2 – ; ` h 2 æ Þ Ã ç

Š î g p x DPM w Þ Ã ç Ï q ` o | Person grammar model [6] › ; M h } f w Þ Ã ç w Ï › $ 5 t Ô b } \ • x 2 æ w ç " Ä Ñ Ÿ ç » › ~ " Ý w Í " À t ü Â ` h Þ Ã ç p K " } ‡ h | ¦ « ç " ´ ã ï Ñ Ÿ ç » › ‹ Q o S " | < R t

(a)Parts (b)Sub-parts (c)Deformation costs

$ 5 Person grammar model

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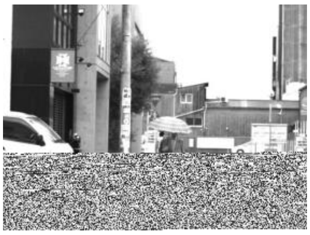
¶ 6 Ã ” »	Í	1,673	1,857	1,763 (95%)

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