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Θ ϡ ϖ ή ʷ э д ˛ ᵈ ӟ ο ȁ ᵈ ӟ ɤ Ɑ ς ρ ϫ ӿ ╓ ӟ ˀ ▸ υ Ι ο Ѐ ɤ ή " ᵈ ӟ υₒ Σ ū Φ ū ɤ ˘ ű ɰ ˋ ς ḧ ű ɰ ώ υ Ώ ᴬ ς λ Κ ν ⌈ ű ɰ ʻ. υ Є Б з є э Ь д F ȁ Ι ο Ѐ ξ φ " э д ˛ ᵈ ӟ ο ȁ ᵈ ӟ ɤ ᵈ ˀ ϫ ӟ ξ α Ч ɰ Ϊ ο ρ Φ Ɑ ς ű ɰ Ϊ ο φ ξ Τ ρ Ρ κ ζ ʻ ή Ρ ή " ϊ ζ ρ ╓ ӟ ˀ ▸ ς Ә Ш Σ ς ρ Ш " э д ˛ ʎ ο ȁ ʎ ɤ ᵈ ˀ ϫ ӟ ξ ˾ ϰ ‴ ɘ β ζ Ι Σ ς ρ κ ζ ζ ϙ " ξ φ ˘ ο ȁ υ Ι ɤ ή ζₒ ū Τ υ ˘ ˋ ɤ ɘ ű ɰ ʻ
þ ˛ κ ˛ Д RGB-D §Ýȁ| œV w * □| SVM

A preliminary study on the estimation of human orientation using an integrated RGB-D sensor

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Abstract In this paper, we report a preliminary study on estimation of human orientation using an RGB-D sensor. We propose a method to smooth a depth image using an RGB image and estimate a human orientation using features of both RGB and depth. We experimentally confirmed the e□ectiveness of our proposed method.

Key words RGB-D sensor, Human orientation estimation, SVM

1. φ ί ϙ ς

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ITS px–2 s 8 h—
L Mo 2]t
oM 8tSMo–)es ht2
O xO p –7t2
O O p –2 V MO
r p–2 tSSf M
pV–st o pV f pCp
x–hT O o—
o V OtmMo

V t o–hT N
C oM [1]- [6] hT
— d p
N O [4] — p
N O [5] oM h–6
O oS –7s N h 6 p—
s t O
p C oM [5] [6]
p—N x— T
GV mt pV mx C RGB
h MhO–OmxmC Depth h
MhOp C MhN px— RGB h

[1] [3]

p Nt M
pV h MT
pV T RGB h M= o
VM pVsM
tMoM) oM
M
t0 mC MhN px
VC N] t6 pN
O [5] [6] p
pV h
m 0sh S pV
T CsMh
p
Ot C MhO mC Mh
Otx fg = O f p
C mC M fg
p SsN V Dts
p C mC
t xC oMsTlh f h RGB h
Depth h txsMO M 7
px txht pVs
Tlh ft RGB h Depth htxcc
C J ah RGB h
Depth ht Ox o sTlh
T h RGB-D C Dso
htC h htmMoxto
t RGB h Depth hp O
hhsO D slh
hs Jt p RGB h Depth
h MoMhOC2 d SsN
V pVD oVh
RGB h pxp lh
Depth h M p D slh
ot Depth h pxp lh
RGB h M p D slh O
t M Mh Jt C
mCp O pVOtslh p
M = 4Op D s RGB h Depth
hdhhs Dtslh
T M tJ fx
Depth ht a p
MhT h t
hM tc V S
D f h Depth ht0 o
O h p C oMs
Tlhh C mCdhtm
MoGs oMsM f h V
ts d

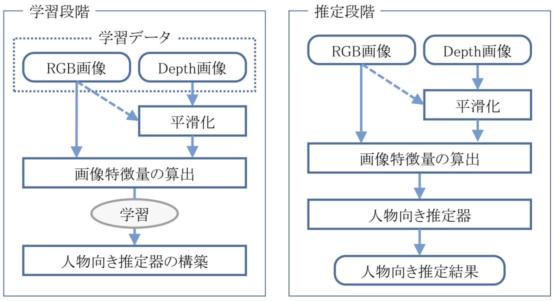
f pCpx e Depth h tmMo
RGB h Depth h t T o
=OMO t RGB h Depth h
dhtmMo Mdh M
oV OO V V
ts dtmMo O
m tmMo oh L
t V tSMo tmMoC

2. RGB-D

ToF Time-of-Flight
M oM MhMOx
M - S M s
M Mlh= px ToF M m
oM ToF M mx h S
h Ct pV
sTlh f h C mCxsT
TsTlh t RGB h Depth h
txc c a h p
O p lh
htC h px o toD
RGB IRt pV f
h ToF M p
C mC pV t
RGB h Depth hc a d s
pV hp O D slh
d s slh p
h do D slh
T Mo Depth hx
M MOJ t RGB ht o Depth
hx M C h x RGB-D
CpVMp o to RGB IR
h t IR M f h
Depth ht a =t4
s

3.

RGB-D C Dso tR
h RGB-D Mo h RGB
h Depth hT ht M
Cp Vx 45° 8 M
V O c rgOt
Depth ht0 o=O t h S RGB-D
Mo h Depth htx
f p sM RGB h o Depth h
=O t 6tV +
+ xrgp 6 RGB
hS Depth hTh o f



1 r g w
Fig. 1 Flowchart.

V] t 6 b ﬂ pﬃ h ﬂ T V b ﬂ
h w b ﬂﬃ 7 tﬃ r g p ﬃ V
b ﬂ h T h ﬂ ﬃ f t h
M o V b ﬂﬃ r g w 1 t
px–e Depth h =tmMo
f —t h tmMo— RGB h
— Depth h t 7t–V
+ V tmMo

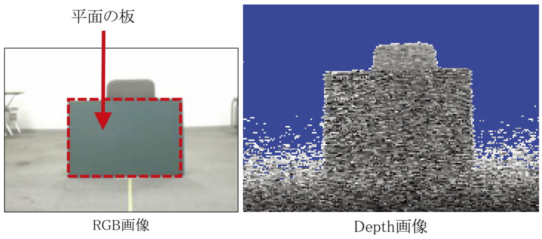
3. 1 Depth

ϖ α " 2 t hh xm
DepthD= hhp –T(tn —r
m M oM hp hx -
DmMtp TpVO
t— Depth htx- Oss aoM
f h–n ht=O
Mh= Mt—sM h
pLt=OO oM
[7] [8] x–h h
)tahO) Mt—sMh
h pLt=O V M
hx— o hh—
s Otd h RGB h
Depth h MoM
Op px RGB-D CpV
h— RGB h Depth hp d s —
pV f p—
sM RGB h Mo–t
Depth h=
x p

$$g(i,j)=\frac{\sum_{n=-w}^{w}\sum_{m=-w}^{w} d(i+m,j+n)w(m,n)c(f)}{\sum_{n=-w}^{w}\sum_{m=-w}^{w} w(m,n)c(f)} \quad (1)$$

$$w(m,n)=\exp(-\frac{m^2+n^2}{2\sigma_1^2}) \quad (2)$$

$$c(f)=\exp(-\frac{(f(i,j)-f(i+m,j+n))^2}{2\sigma_2^2}) \quad (3)$$



2 w h h
Fig. 2 Image of flat board.

O p ﬀy Depth — d
w Depth — f , RGB p
h— σ_1, σ_2
(i,j) xh 2— m, n
w $m\sigma$ w σ w σ w σ
w m σ RGB h)
M—r—htGVsO) —= M
t px—
th)tahO s—s=
sM MOD T —
px—M Depth h ht —
sM RGB h h M p—sO
) =

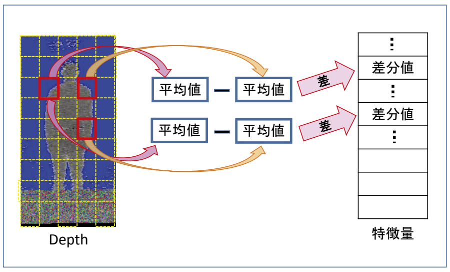
3. 2 RGB

RGB hTx—
pV Vtlo h
h— xV t h—
x— Depth hTxsMCp
— —s Mt

T— RGB hT o—
ts f h—
Opx Histograms of Oriented Gradients HOG

3. 3 Depth

Depth hTx—
pV x SSf V
pVh–V t
V ts Depth h o— RGB
h 7tts –mh
ts
x pV M–mh
x
pV— V pV
ts o— RGB h 7t
HOG h–mh
o— Depth) V
tSMox— V Os
f h–Opx
Depth) o tx–h



3 Depth h w ﬄ m h w Depth w)ﬃ
Fig. 3 Feature of depth.

w w G V w t ﬃ f w T m w
R oﬃ w Depth - of)
f o— o ppht-
h — o 3

3.4 ｏ ｕ Ｔ ｂ

ｄ ｊ Ｐ 45° 8 M h—
CpxV 8 M J o
O lo px–h t 8 M McT
tO+
+ x— 1 (t h6 t
O c— RGB h = h Depth hTh
h RGB h Depth h
–d Mo+
6 + 6tx SVM
t–V] h6
6t h SVM +–V t

3.5 ｏ ｕ Ｔ ｂ
ｏ ｕ Ｔ ｂ φ 1 t h
tO c—+ V 7t— RGB h
= h Depth hTh
hd–f t6p h
V + Mo—V

4.

RGB-D Mo hht0 —
O oV glh
gpx— 3 M–f LtmMo
olh

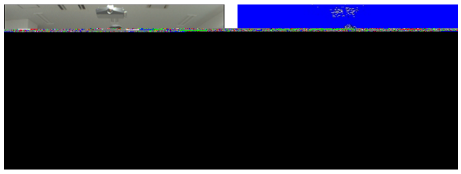
- Depth h =O sM
- Depth h tmMo–ts

mh

- RGB h Depth h dh

M

4.1
RGB h S— Depth h x— RGB-D
Ds Panasonic MN34901TL
eL h RGB-D Mo lh rSx
RGB h 640×480 h— Depth h 320×240 hp



4 RGB h S Depth h w
Fig. 4 Samples of RGB and Depth image.

ﬂﬃRGB-D T 3m t m –
1,347 h h h x 45° 8 M
McT MMoM
h 4 t x Depth hp —
T(tn —rm M oM h—
hp hx -DmMtp
4 hpx— 4m S mp- oMh—
M hp oM

4.2
1,347 hx— 20 5 hh
p V gpx— 5 O 4 h
+ 6t — 1 Mo
V —S lh 5 M—
S O V S S p
x— L rp h

4.3 1 Depth
Depth h =
LtmMo–=O sM pV
S lh L 1 t V
tx–ts p HOG
Mh Depth hT HOG –f6
o + h f + MoV
M–f L t S lh

4.4 2 RGB h
Mh— Depth h ts
Mh— Depth h mh
Mh— RGB h Depth h
dh Mh V S lh
RGB h px— HOG Mh Depth h
px–ts o HOG
–mh o
Depth)fg Mh RGB h Depth h
dh px— RGB h o HOG
— Depth h o Depth)
Mh
hT –f6 o +
h f + MoV M–f
L t S lh f L 2 t

5.

Depth h = –V

1 g A L 1ffi t fl Lffi

O	Y r p
s	68.8 ffi
K	76.2 ffi

t s h fl t m M offi f g o l hffi

5.1 Depth ᵈ ǯ υ ʲ ⊐

1 t hOt— Depth h =lhM —
=sM o–V S
h
1 gpx— Depth h HOG Mo
V lh HOG x-t h
S p —
=sM Depth htx oS—
=lh p n h t–V
St h lo—
t= pVh
h=t S GV h TO
RGB-D MoV tx— Depth
ht0 o =rg p

5.2 ᵒ Ū T υ ρ ᵈ ǯ

ϖ α " Depth h tmMooO 2 t
hOt–mh M –t
s o–V S
h
S h o–m
mx— ts –e
M –V t MO p s
— OsITs—GT
s M V p
Omx–p Op RGB-D
x Depth ht –=loMo
tnpV pxsM f h—
OsITsx—t t
pVc—GTs M tM
h
t— h o h o–V
t sh tmMoo O 2 t hO
t— RGB h Depth h dh V
V S 7 Sp RGB h M
h S Depth h Depth) Mh
SxSp h–dh pV
S h T h lo— RGB h
Depth h d –V
tSMop pVh

6. Ϙ Ű ï

RGB-D MhV tmMo —
lh c— T o Depth h =
M–g o h t— Depth h

2 S A 2ffi Depth h fl w z ffi

O	Y r p
RGB h w	88.1 ffi
Depth h w ffi HOG flffi	76.2 ffi
Depth h w ffi Depth)ffi	87.0 ffi
RGB h Depth h	95.1 ffi

fl t m M o U ffi t s m h w fl
h fl Uffi V w t p K fl
hffi 7 tffi RGB h Depth hT
do t–V
S h
]J o— RGB h Depth hT
dMO —— RGB-D C D
s T hhs p C
px— RGB h Depth hTfg h
–floV t h f h—
RGB-D CD MO Gt oMs
M Ct–d pV
S hh–xt Mhhs
tmMo —oM p

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