**The process of image analyses**

Images were processed as follows, 1. Downsize images into 8 × 9 pixels to remove the image details and retain only robust information such as the structure, light, and shade; 2. Convert downsized images into grayscale to simplify the comparison dimension; 3. Produce a 64-bit ‘hash fingerprint’, with ‘1’ indicating the pixel intensity is increasing and ‘0’ indicating it is decreasing in each line; 4. Calculate hamming distance, the number of positions in which the corresponding bits differ between two strings of hash fingerprint: d(x,y) = ∑x[i]⊕y[i]; 5. Calculate similarity score: Sim = [1-d(x,y)/64] × 100. Sim indicates similarity level between two images (the larger the value, the more similar two images are) and was used to detect previously seen images. For monitoring real-time withdrawal speed, to mimic the human perceptual system that promotes longitudinal coherence over short-lived information, the weighted average method was used to analyses the similarity of 10 successive frames according to the formula, where Simi is the similarity score between frames n and n-(10-i). Deviation score was further calculated as: = 100 -, indicating weighted average deviation level among 10 successive images.

**Withdrawal speed threshold**

In the previous study, the correlation between withdrawal time and average withdrawal speed was assessed on the 84 colonoscopy videos. Mean colonoscopy average withdrawal speed and withdrawal time were significantly negatively related. 95% CIs for withdrawal speed for colonoscopy with a withdrawal time exceeding 6 min, 5–6 min, and less than 5 min were 36.15–40.14, 40.24–44.46, and 44.54–49.96, respectively (there are no units for withdrawal speed). Therefore, less than 40 was judged a safe withdrawal speed, 40–44 was the alarm withdrawal speed (ie, to take note that the speed was slightly too fast), and more than 44 was judged a dangerous withdrawal speed (ie, too fast).

**Data sets**

The datasets were used for training and testing the model. We trained and tested deep convolutional neural networks (DCNNs) on still images. For the first dataset (DCNN1), we used 10634 cecum and 14686 non-cecum images were selected for training the network to recognize the cecum. 1468 non-cecum images and 1063 cecum images were used as the testing set. For the second dataset (DCNN2), we used 3264 biopsy instrument, 10180 polypectomy instrument and 4320 no instrument colonoscopy images for training the network to filter out the frames of biopsy and polypectomy. 1000 images per category were used as the testing set. For the third dataset (DCNN3), we used 3264 in-vitro and 10180 in-vivo colonoscopy images for training the network to identify whether a scope was inside or outside the body. 1000 images per category were used as the testing set. Three experts with more than 5 years of colonoscopy experience labeled these images and ‘two out of three’ principle was taken. These images came from stored data of over 10000 patients. Extensive attention was paid to ensure that images from the same person were not split between the training and testing sets. All the colonoscopy images and videos were from Renmin Hospital of Wuhan University.

**Tables**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table S1. Baseline information for ST-HP group, ST-LP group, NT-LP group and NT-HP group.** Data are mean (SD) or n (%). ST-HP group: withdrawal time > 6 min and the POF >10%, standard withdrawal time and high POF; ST-LP group: withdrawal time >6 min and the POF ≤10%, standard withdrawal time and low POF; NT-LP group: withdrawal time ≤6 min and the POF ≤10%, nonstandard withdrawal time and low POF; NT-HP group: withdrawal time ≤6 min and the POF >10%, nonstandard withdrawal time and high POF. | | | | |
|  | ST-HP group  (n=206) | ST-LP group  (n=589) | NT-LP group  (n=809) | NT-HP group  (n=200) |
| Age (SD) | 52.08(13.57) | 51.68(12.82) | 53.12(12.14) | 50.73(13.06) |
| Sex |  |  |  |  |
| Male sex | 100(48.54) | 298(50.59) | 348(43.02) | 93(46.50) |
| Female sex | 106(51.46) | 291(49.41) | 461(56.98) | 107(53.50) |
| Indication for colonoscopy |  |  |  |  |
| Screening | 62(30.10) | 309(52.46) | 648(80.10) | 89(44.50) |
| Diagnostic | 122(59.22) | 233(39.56) | 113(13.97) | 92(46.00) |
| Surveillance | 22(10.68) | 47(7.98) | 48(5.93) | 19(9.50) |
| Recruitment |  |  |  |  |
| Inpatient | 41(19.90) | 147(24.96) | 156(19.28) | 63(31.50) |
| Outpatient | 165(80.10) | 442(75.04) | 653(80.72) | 137(68.50) |
| Brand of colonoscopy |  |  |  |  |
| Olympus | 147(71.36) | 353(59.93) | 476(58.84) | 107(53.50) |
| Fujifilm | 59(28.64) | 236(40.07) | 333(41.16) | 93(46.50) |
| Bowel preparation |  |  |  |  |
| BBPS≥2 in all segments | 171（83.01） | 484（82.17) | 594(73.42) | 139(69.50) |
| BBPS<2 in any segment | 35（16.99） | 105(17.83) | 215(26.58) | 61(30.50) |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table S2.ADR and PDR at different withdrawal time for the whole colon.** Data are shown as n (%). n=number of patients. (%) = proportion of the patients. | | | | | |
|  | withdrawal time | | | | |
|  | 0-3min  (n=290) | 3-6min  (n=719) | 6-9min  (n=612) | ＞9min  (n=183) | Pearson correlation coefficient |
| ADR (%) | 15.86 | 21.28 | 20.26 | 32.24 | 0.892 |
| PDR (%) | 56.55 | 55.08 | 58.66 | 84.15 | 0.810 |

ADR, adenoma detection rate; PDR, polyp detection rate.

**Table S3. The effect of different POF on ADR in subgroup analysis.** Data are shown as %. % = proportion of the patients. \* These data are shown as P value, mean range (95% CI). LP group: the POF ≤10%, low POF; HP group: the POF >10%, high POF.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | ADR | | P value | Odds ratio (95% CI) |
|  | LP group | HP group |
| Indication for colonoscopy |  |  |  |  |
| Screening | 20.59 | 13.91 | 0.07 | 0.626（0.378-1.037） |
| Diagnostic | 27.75 | 15.89 | ＜0.01 | 0.438（0.275-0.699） |
| Surveillance | 28.42 | 17.07 | 0.08 | 0.404（0.146-1.121） |
| Age |  |  |  |  |
| ≤49 years | 14.42 | 5.26 | 0.01 | 0.337（0.141-0.804） |
| ≥50 years | 24.55 | 20.15 | 0.01 | 0.646（0.460-0.906） |
| Bowel preparation |  |  |  |  |
| BBPS≥2 in all segments | 23.56 | 15.16 | ＜0.01 | 0.518（0.359-0.745） |
| BBPS<2 in any segment | 20.63 | 15.63 | 0.15 | 0.615（0.318-1.189） |
| Sex |  |  |  |  |
| Male sex | 26.16 | 18.65 | 0.01 | 0.580(0.374-0.897) |
| Female sex | 20.08 | 12.21 | ＜0.01 | 0.486(0.304-0.777) |
| Recruitment |  |  |  |  |
| Inpatient | 25.74 | 12.50 | 0.02 | 0.437(0.224-0.853) |
| Outpatient | 22.10 | 16.23 | ＜0.01 | 0.570(0.394-0.824) |
| Brand of colonoscopy |  |  |  |  |
| Olympus | 23.76 | 17.72 | 0.01 | 0.602（0.405-0.894） |
| Fujifilm | 21.62 | 11.18 | ＜0.01 | 0.435(0.247-0.766) |

POF, proportion of over-speed frames; ADR, adenoma detection rate.

**Table S4. Complementary effects of POF and withdrawal time on ADR in subgroup analysis.** Data are shown as %. % = proportion of the patients. \* These data are shown as P value, mean range (95% CI). ST-HP group: withdrawal time > 6 min and the POF >10%, standard withdrawal time and high POF; ST-LP group: withdrawal time >6 min and the POF ≤10%, standard withdrawal time and low POF; NT-LP group: withdrawal time ≤6 min and the POF ≤10%, nonstandard withdrawal time and low POF; NT-HP group: withdrawal time ≤6 min and the POF >10%, nonstandard withdrawal time and high POF.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ADR | | P value | Odds ratio (95% CI) | ADR | | P value | Odds ratio (95% CI) |
|  | ST-LP group | ST-HP group | ST-LP group | NT-LP group |
| Indication for colonoscopy |  |  |  |  |  |  |  |  |
| Screening | 21.36 | 14.52 | 0.18 | 0.579（0.262-1.280） | 21.36 | 20.22 | 0.91 | 0.979（0.688-1.393） |
| Diagnostic | 27.04 | 15.57 | ＜0.01 | 0.358（0.193-0.664） | 27.04 | 24.78 | 0.39 | 0.785（0.453-1.360） |
| Surveillance | 31.91 | 27.27 | 0.26 | 0.483（1.135-1.731） | 31.91 | 25.00 | 0.40 | 0.651（0.239-1.775） |
| Age |  |  |  |  |  |  |  |  |
| ≤49 years | 14.69 | 2.70 | 0.02 | 0.154（0.034-0.697） | 14.69 | 13.41 | 0.99 | 0.993（0.425-2.321） |
| ≥50 years | 28.70 | 24.24 | 0.04 | 0.600（0.372-0.966） | 28.70 | 22.01 | 0.25 | 0.843（0.632-1.125） |
| Bowel preparation |  |  |  |  |  |  |  |  |
| BBPS≥2 in all segments | 25.62 | 15.20 | ＜0.01 | 0.396（0.237-0.661） | 25.62 | 21.89 | 0.21 | 0.822（0.606-1.116) |
| BBPS<2 in any segment | 23.81 | 22.86 | 0.63 | 0.786（0.297-2.080） | 23.81 | 19.07 | 0.82 | 0.932(0.507-1.715) |
| Sex |  |  |  |  |  |  |  |  |
| Male sex | 28.86 | 19.00 | ＜0.01 | 0.419（0.225-0.7830 | 28.86 | 23.85 | 0.19 | 0.774(0.528-1.315) |
| Female sex | 21.65 | 14.15 | 0.04 | 0.497(0.259-0.950) | 21.65 | 19.09 | 0.72 | 0.931(0.631-1.372) |
| Recruitment |  |  |  |  |  |  |  |  |
| Inpatient | 25.85 | 14.63 | 0.07 | 0.399(0.147-1.087) | 25.85 | 25.64 | 0.38 | 1.290(0.732-2.273) |
| Outpatient | 25.11 | 16.97 | ＜0.01 | 0.469(0.283-0.777) | 25.11 | 20.06 | 0.09 | 0.761(0.553-1.048) |
| Brand of colonoscopy |  |  |  |  |  |  |  |  |
| Olympus | 25.50 | 15.65 | ＜0.01 | 0.399(0.228-0.698) | 25.50 | 22.48 | 0.91 | 0.981(0.691-1.392) |
| Fujifilm | 25.00 | 18.64 | 0.10 | 0.528(0.246-1.130) | 25.00 | 19.22 | 0.16 | 0.729(0.469-1.133) |

POF, proportion of over-speed frames; ADR, adenoma detection rate.

**Table S5.ADR at different withdrawal time and POF for the whole colon.** Data are shown as %. % = proportion of the patients. \*These data are shown as P value, mean range (95% CI).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | POF≤10% | POF＞10% | P value | Odds ratio (95% CI) |
|  | withdrawal time |  |  |  |  |
| ADR | ＞9min | 31.69 | 34.15 | 0.55 | 0.779（0.342-1.771） |
| ≤9min | 21.89 | 13.15 | ＜0.01 | 0.500（0.351-0.711） |
| 6-9min | 23.27 | 12.12 | ＜0.01 | 0.395（0.227-0.684） |

POF, proportion of over-speed frames; ADR, adenoma detection rate.