Human Blastocyst Classification after In Vitro Fertilization Using Deep Learning

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Introduction

- Visual assessment of embryo quality after IVF by embryologists
- Variability among assessors remains one of the main causes of the low success rate of IVF [1]
- Recent studies also explored the possibilities to automate embryo assessments for IVF [2, 3, 4] from day 5 embryo images
- Can we do it with day 3 embryos which only require simple salt solution for the media?

Dataset

- A total of 1084 images from 1226 embryos of 246 IVF cycles at Yasmin IVF Clinic, Jakarta, Indonesia
- Captured by an inverted microscope at day 3 after fertilization
- A team of 4 embryologists graded them 1-5 by using Veeck criteria [5], but there is only grade 1 to grade 3 embryos in the samples
- This yields 1226 images consisting of:
  - 459 grade 1
  - 620 grade 2
  - 147 grade 3
- Preprocessed using fast.ai default preprocessor

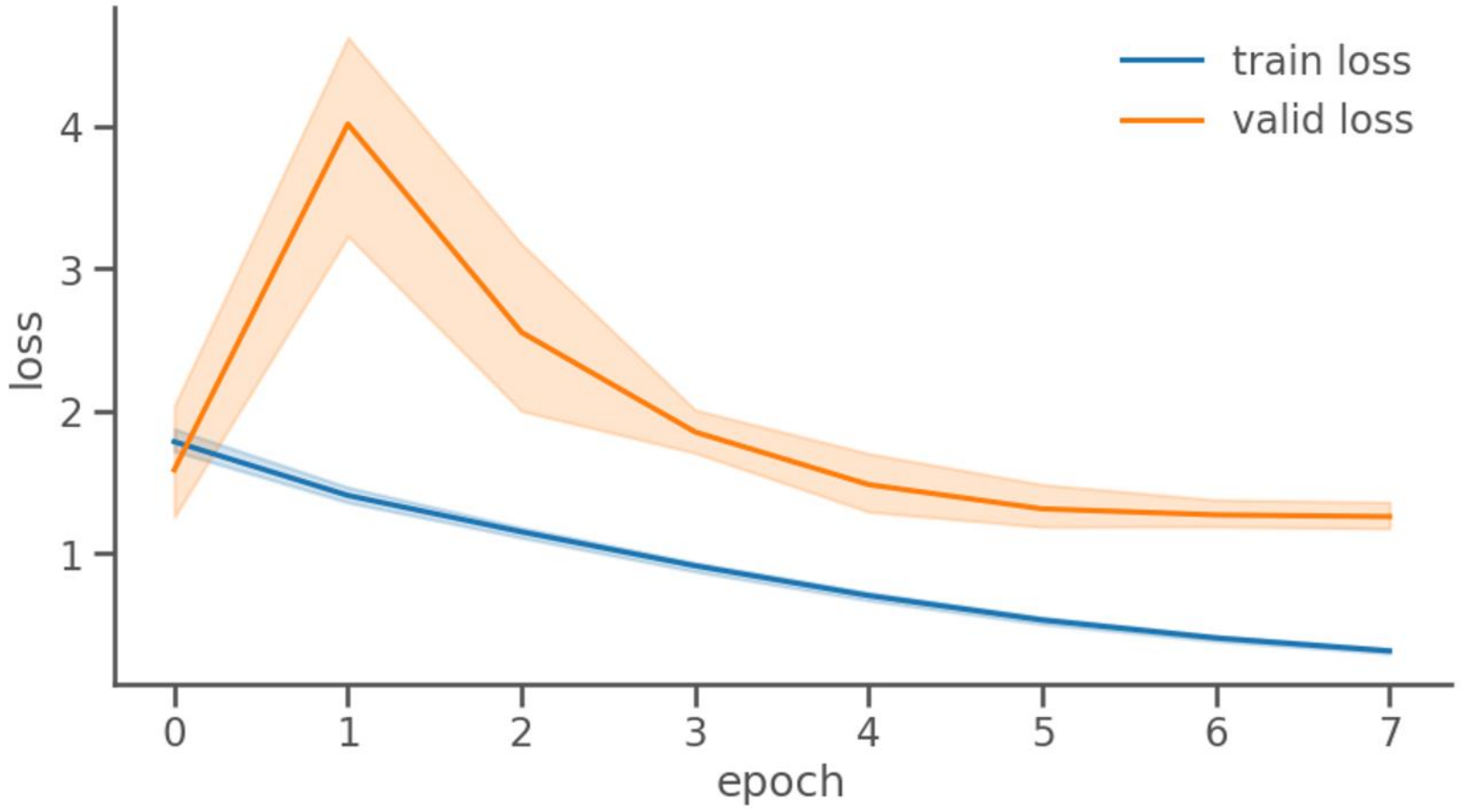
Methods

- fast.ai library, cyclical learning rate
- Fine-tuning pre-trained convolutional neural networks:
  - ResNets
  - DenseNets
  - Xception
  - MobileNetV2
- Repeated 5 times to get the average results due to randomization

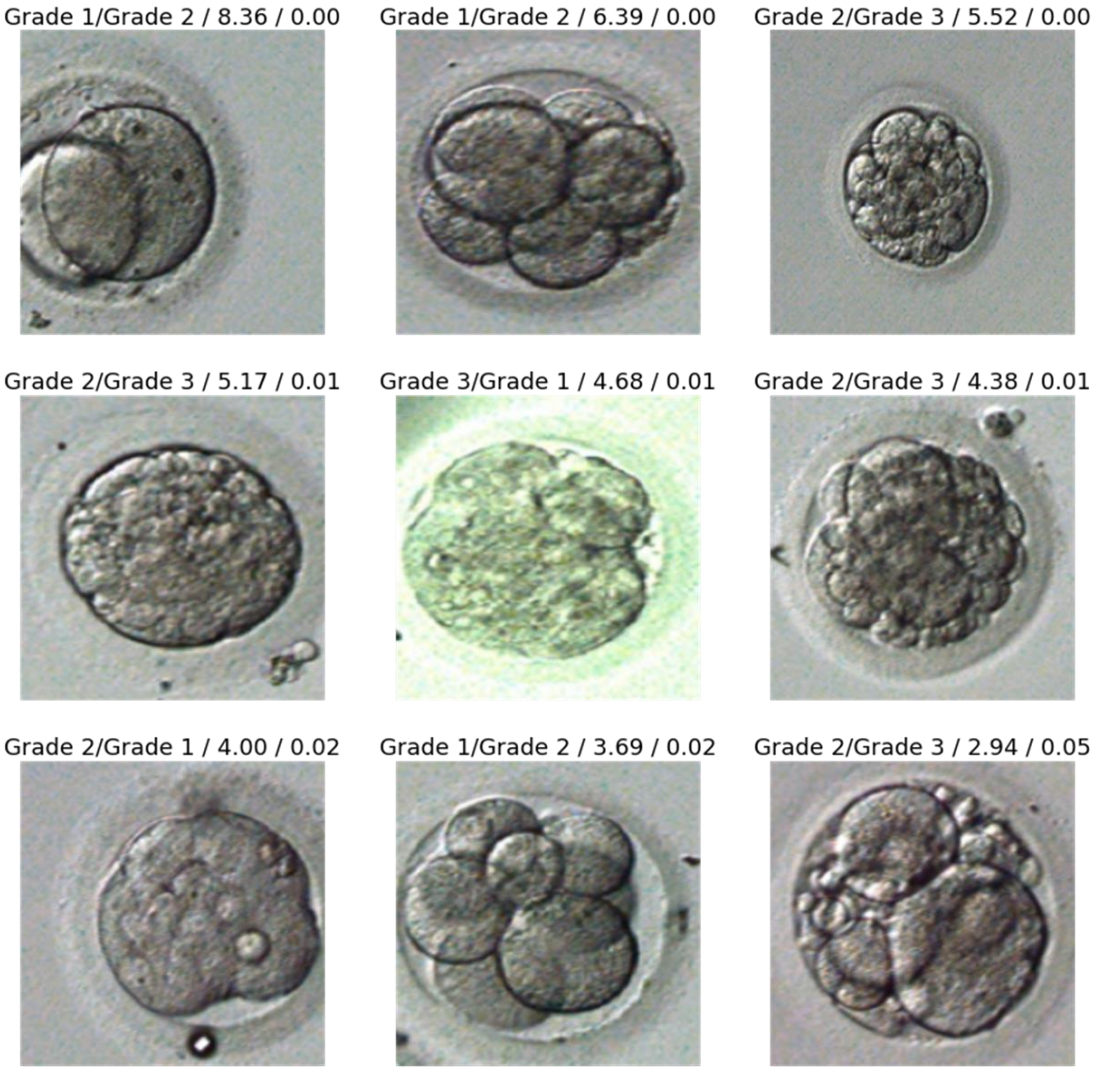
Results – Model comparison

model	accuracy	loss
ResNet18	$89.38\% \pm 0.75\%$	0.3312 ± 0.0330
ResNet34	$89.97\% \pm 1.27\%$	0.3495 ± 0.0343
ResNet50	$\mathbf{91.79\% \pm 0.48\%}$	$\mathbf{0.3114 \pm 0.0253}$
ResNet101	$91.07\% \pm 1.00\%$	0.3749 ± 0.0623
DenseNet121	$89.97\% \pm 0.27\%$	0.3567 ± 0.0365
DenseNet169	$91.14\% \pm 0.54\%$	0.3472 ± 0.0366
Xception	$88.86\% \pm 0.96\%$	0.3209 ± 0.0206
MobileNetV2	$91.14\% \pm 0.84\%$	0.3442 ± 0.0258

Results – Learning curve



Misclassified images



Conclusions

- Best accuracy of 91.79% by ResNet50
- More complex models failed to achieve better accuracy
- MobileNetV2 with fewer parameters achieved 91.14% accuracy, very close to the best model
- Problems in different shades of colour and digital obstructions from the image processing software

References

[1] Bendus, A.E.B., Mayer, J.F., Shipley, S.K. and Catherino, W.H., 2006. Interobserver and intraobserver variation in day 3 embryo grading. *Fertility and sterility*, *86*(6), pp.1608-1615.

[2] Khosravi, P., Kazemi, E., Zhan, Q., Malmsten, J.E., Toschi, M., Zisimopoulos, P., Sigaras, A., Lavery, S., Cooper, L.A., Hickman, C. and Meseguer, M., 2019. Deep learning enables robust assessment and selection of human blastocysts after in vitro fertilization. *NPJ digital medicine*, *2*(1), pp.1-9.

[3] Kragh, M.F., Rimestad, J., Berntsen, J. and Karstoft, H., 2019. Automatic grading of human blastocysts from time-lapse imaging. *Computers in biology and medicine*, *115*, p.103494.

[4] Chen, T.J., Zheng, W.L., Liu, C.H., Huang, I., Lai, H.H. and Liu, M., 2019. Using Deep Learning with Large Dataset of Microscope Images to Develop an Automated Embryo Grading System. *Fertility & Reproduction*, *1*(01), pp.51-56.

[5] Veeck, L.L., 1999. *An atlas of human gametes and conceptuses: an illustrated reference for assisted reproductive technology*. CRC Press.

Thank you

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