Al estimation of gestational age based on microscopic appearance of placental villi

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Background – The Placenta



- First organ to form
- Source of fetal O2 + nutrients
- Endocrine, immune, barrier, excretion functions
- Causes or reflects most diseases in pregnancy
- Branching structure:
- UC->Capillaries
- Capillaries -> UC

Research Objectives – The Task

Estimate gestational age (GA) from 24 to 42 weeks 5+ clnical criteria

- Villi thinner
- Stroma fewer $\mathbf{M}\phi$ and **F**ibroblasts
- Stroma denser
- **C**apillaries under surface
- Knots

Gestalt across criteria + fields 36k fields, 500k cells on one slide Aggregation / attention



The Problem – Interobserver Variability

29,943 placentas, 9.5 years, 8 pathologists

Appropriate for gestational age: 17,806 (60%), Range 51 – 77%

Accelerated: 5108 (17%), Range 8.2 – 27%

Delayed: 1024 (3.4%); Range 0.2 – 13%

Mixed / variable / no diagnosis rendered: 6005 (20%); Range 4 – 24%

Significant interobserver variability



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Methods - Network



Randomly sampling ROIs to form Glimpses: ROI spit into HPF. HPF randomly sorted into glimpses; glimpses distributed into batches.



Model pipeline: Glimpses are submitted to a feature extraction network based on *VGG19 (blue); intermediate input (red squares) are fed to a multilayer perceptron* attention subnetwork (green) feature maps + attentions are weighted + aggregated (pink) ; representation learning subnetwork (yellow) estimates GA; mean squared error is used for back-propagation

Results - Accuracy









weeks

Results – Whole slide attention

Top – attention over a whole maternal surface biopsy

The model recognized terminal villi with uniform high positive attention (Red areas, top panel and lower right). Decidua showed variably positive attention. Large stem vessels, trophoblasts, and blood were generally marked with negative attention (Blue areas).

Results - Whole slide GA estimation

36 new slides, without ROI annotation

- Determine attention + estimated GA for nonoverlapping fields
- Attention cutoff based on validation slides
- r^2: 0.8859, MAE 1.3671 weeks, 35/36 correct within 3



Conclusions

- Can predict gestational age from microscopic slides with high accuracy
- Clinical use when GA is unknown
- Could predict from a single human-selected ROI
- Quality improvement / improve interobserver variabili
- Utility of Glimpse for aggregation + attention
- Next steps
 - Problems with maturation (preeclampsia, diabetes)
 - Generalizability to different sites
 - Quantitative description of changes during gestation

