Case Study

Service Providers
Artificial Intelligence

Using AI to Improve Women's Chances of Conceiving

Using the Intel-optimized machine learning platform from Ximilar, Babyndex has launched the first[1] microscope and AI-linked app solution for evaluating saliva crystals, enabling women to identify their most fertile days.

One out of six couples have difficulty getting pregnant despite trying for more than a year[2]. This situation can be hugely frustrating, especially for those women with irregular cycles who are trying to conceive. To help these women better know their fertile days, Babyndex has developed a solution that combines a simple saliva test and an ovulation microscope with an artificial intelligence (AI)-powered app.

Using computer vision and machine learning, the app helps women easily and more accurately[3] identify saliva crystals. By identifying the crystals that correspond with their fertile window, women can improve their chances of conceiving. To develop and deploy the app's advanced algorithms, Babyndex turned to the MedTech Visual AI specialists Ximilar and their Intel-optimized machine learning platform.

Challenge

- Women using ovulation microscopes to help them conceive sometimes struggle to identify correctly saliva crystals using the naked eye. Their most fertile days pass without their knowledge.
- Babyndex wanted to develop an AI-supported app that helps women better identify saliva crystals. However, it was only able to collect a limited image dataset to build and train its algorithm.
- Returning accurate AI inference that meets user expectations requires huge amounts of computing power with low latency.

Solution

- Babyndex worked with Visual AI services provider Ximilar to build, train, and deploy its machine-learning algorithm using its limited dataset.
- Ximilar's innovative 'Flow' approach–breaking down complex machine learning problems into smaller, separate tasks, and chaining them into one image-processing flow–enabled Babyndex to improve the accuracy of its models over time.
- As a member of Intel® AI Builders, Ximilar has early access to Intel's technology roadmap, enabling it to optimize its machine learning as a service (MLaaS) platform to run inference on Intel® processors in the cloud.

Results

- Ximilar's modular flow approach and Intel-optimized MLaaS platform has enabled Babyndex to launch the first app that automatically recognizes saliva crystals, helping women to identify their fertile days.
- Ximilar now runs all its models on standard Intel CPUs rather than dedicated accelerators, helping–among others–Babyndex to improve hardware utilization and save costs.
- Babyndex enables women to *accurately* identify their *actual* fertile window in an *affordable* way by digitalizing the saliva ovulation test and saves the data to a personal calendar.

Using saliva crystallization to identify fertile days

Most fertility monitoring apps rely on basal body temperature (BBT) tests or Luteinizing Hormone (LH) urine tests that predict ovulation only +/- one day ahead. But the fertile window starts five days before ovulation. This anomaly means BBT- or LH-based monitors must collect at least three cycles' worth of ovulation data to feed a sophisticated predictive algorithm.

However, even the best algorithms can't make a prediction if a woman's cycles are irregular–for example, those women approaching menopause. Less obvious biomarkers must be measured to enable these women to know their most fertile day (two days before ovulation).

One of these indicators is the estrogen hormone increase that correlates with the structural change in body mucus. Increasing salt levels cause fern-like saliva crystals to form. On fertile days, air-dried saliva crystallizes for most women. Using either an expensive electrolyte detector or an ovulation microscope, women can try to identify saliva crystals to work out when there's a high chance of getting pregnant.

Most women currently use their naked eye to decide whether there are crystals or not. Sometimes, they don't wait long enough for the crystals to dry. The amount of saliva in the sample may be too much or they can't identify crystals.

To help these women, Babyndex set about developing an app that uses image recognition technology based on computer vision and machine learning algorithms. The AI-enabled app identifies saliva crystallization more easily and accurately. In addition, the app keeps a personal ovulation calendar. If the user can see consecutive days with a significant level of fern-shaped crystals, she can assume she is in her fertile window.

Collating a dataset of saliva crystal images

Developing, training, and deploying a computer vision model brings huge challenges with regard to the precision and performance of image recognition. In the development phase, the accuracy of labeling and classification of the data features required for the use case is critical. For Babyndex, this problem was further complicated, since it had a very limited number of images from which to build up an operational model.

Zajzon Bodó, co-founder, and coinventor at Babyndex, explains: "In the initial development phase, we collected a few hundred images of dried saliva samples with saliva crystals. This exercise may sound easy, but it took more than two years."

"Most women use hormonal contraception and trick their bodies into thinking they're pregnant. They don't ovulate or have fertile windows or saliva ferning. Those women who don't use contraception and visited the Babyndex gynecologist were asked to give a saliva sample. However, only a few of them were right before ovulation and had saliva crystals."

Building an operational model from such a limited dataset was going to be challenging. Nevertheless, Babyndex wasn't deterred and, after filing a patent application in 2016, it began looking for a machine learning provider to help it get its app off the ground.

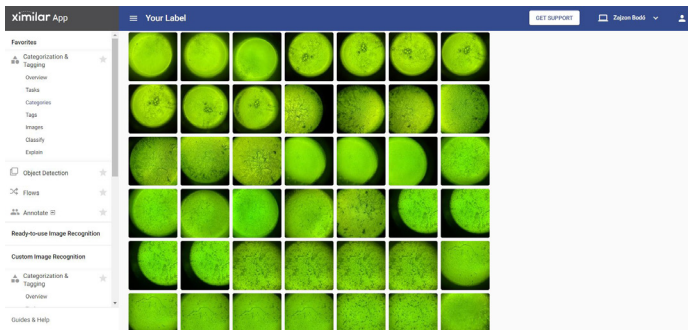

Figure 1. Saliva samples in the Ximilar app.

Building and training models from limited datasets

"Universities and research organizations were extremely expensive, while providers of (at that time new) online image analysis services had either vague offerings or business models," recalls Bodó. "We wanted to detect crystals without additional hocus-pocus and to avoid a lock-in. Then we bumped into Ximilar. They seemed to offer exactly what we needed."

"Nevertheless, we still had concerns related to data protection, performance, and scalability. We organized a meeting. We learned the data was stored in Europe, meaning General Data Protection Regulations (GDPR) wouldn't hinder our startup."

"We also learned that Ximilar had clients in the US. They were aware of the data protection requirements for health and personal data and could also handle scalability issues in both continents. We were convinced and uploaded our initial dataset of a few hundred images and trained our machine learning algorithm. It worked, and its speed was surprisingly and reliably lightning fast."

Together, Babyndex and Ximilar established guidelines for annotating the saliva crystal images. They added metadata to the datasets to label and classify the data features Babyndex wanted its computer vision model to recognize. Babyndex then applied these annotations to a set of models to test which one worked best for its use case.

Once Babyndex decided on the most appropriate computer vision model, it began to train it further, to find the most accurate convergence point for its use case. Finally, Babyndex deployed the computer vision model for inference against previously unseen datasets.

Today, users upload their images and the dataset continuously grows, quickly and easily improving the Babyndex algorithm. "We're quite confident that the professional support in categorizing our image data gives us a long-lasting competitive advantage in identifying the fertile window more precisely," says Bodó.

David Novák, CEO, and co-founder at Ximilar, says: "The Ximilar platform is built for exactly these circumstances: building and training models from small datasets. We break down the machine learning problem into smaller, separate parts like categorization or detection tasks, and then we chain these models back into one image processing flow."

"This approach allows us to improve continuously the quality of separate models while in motion. Applying new, more accurate versions with just one click leaves the rest of the system untouched. We can improve the accuracy of one model without having a negative impact on the accuracy of all the other models. This approach enables us to have such great success with limited datasets."

Optimizing the Ximilar platform for Intel® architecture

Ximilar runs its cloud-based machine learning as a service (MLaaS) platform on both GPUs and CPUs. "Running our infrastructure as efficiently as possible and delivering high-quality results is essential for us," says Novák. "It isn't hard to get incredible amounts of computational power today. Using these CPUs to their fullest potential is where we can differentiate ourselves. We love saving energy, resources, and at the same time providing our services for reasonable prices."

Ximilar works with Intel to optimize the speed of its machine learning platform and improve the efficiency of its infrastructure overall. Ximilar's machine learning models for image recognition are trained in TensorFlow 2+ on GPU cards. They're then further optimized using the Intel® Distribution for OpenVINO™ toolkit. The inference engine then runs the Intel-optimized model on 2nd Generation Intel® Xeon® Scalable processors, serving all the incoming API requests for prediction.

Using the Intel Distribution for OpenVINO toolkit Ximilar can take full advantage of the acceleration capabilities of Intel® Advanced Vector Extensions-512 (Intel® AVX-512)–a feature built into Intel Xeon Scalable processors.

Ximilar now runs all its models on standard Intel CPUs rather than using dedicated accelerators. It saves GPU computing resources that can be used for training, improving hardware utilization to reduce costs.

David Novák says: "We own our own hardware. If the capacity is full, we've got to buy a new server. With these Intel optimizations, the processing of every task on the server is faster, meaning we reach full capacity later. It spares GPU hardware costs for us."

As a member of Intel® AI Builders, Ximilar also benefits from direct access to technical resources and support, and can test, optimize, and integrate future Intel technologies.

Michal Lukáč, co-founder of Ximilar, says: "The cooperation we had with the Intel AI Builders team was flawless and very professional. After seeing the optimization results, I can say that being part of the Intel AI Builders program was one of our most significant achievements this year. We're now able to speed up the system, improve scalability, and save computing resources."

Improving women's chances of conceiving

Ximilar's modular flow approach to building models and training them from limited datasets has enabled Babyndex to launch and improve the first[1] app to help women better recognize saliva crystals. Even women with irregular cycles now have access to an affordable fertility-monitoring app that shows them their most fertile days with high accuracy. The Intel-optimized machine learning platform delivers fast, accurate inference results that meet user expectations.

The AI-enabled app supports women trying to conceive to use their ovulation microscopes. They can predict their fertile days, significantly increasing their chance of becoming pregnant. Babyndex more accurately[3] pinpoints a woman's fertile window, compared with traditional fertility monitors. And it's also more affordable than other tests working with hormones or skin properties[4].

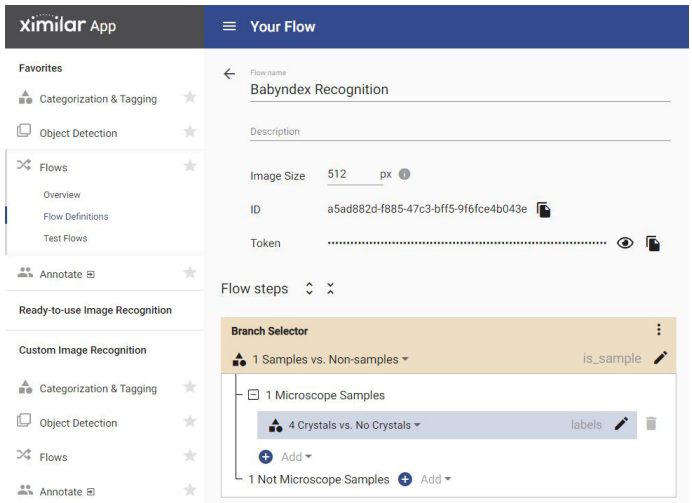

Figure 2. Babyndex flow in the Ximilar app.

Using Babyndex to identify fertile days

1. To use the Babyndex solution, women apply a little saliva to the lens of the microscope supplied by Babyndex and wait for it to dry.
2. Then, using the app they've downloaded to their smartphone, they hold the microscope against the camera and take a picture of the saliva sample.
3. The Babyndex algorithm then analyzes the saliva patterns and determines the probability of crystals.

Looking to the future

Babyndex now plans to extend the app's capabilities beyond machine learning to full AI. It wants to augment the image data with additional personal data, for example, age and weight. By doing so, it hopes to predict the probability of fertility rather than the probability of saliva crystals.

Ximilar is continuing to work together with Intel engineers on its object detection, remove background, and segmentation models. It wants to make them faster without using a GPU. Its aim is to build the best and most easy-to-use platform focused on computer vision, image recognition, detection, and similarity search.

Ximilar is also looking forward to converting more of its services and models with the Intel Distribution for OpenVINO toolkit to speed up the entire platform running on Intel Xeon Scalable processors.

> "The cooperation we had with the Intel® AI Builders team was flawless and very professional. After seeing the optimization results, I can say that being part of the Intel AI Builders program was one of our most significant achievements this year. We're now able to speed up the system, improve scalability, and save computing resources. The marketing cooperation with Intel helps us to show our unique products to more potential customers."
>
> **Michal Lukáč,**
> Co-founder & Machine Learning specialist at Ximilar

About Babyndex

Launched in 2016 in Gödöllő, Hungary, the Babyndex team started to build an automated application that helps women interpret saliva ovulation tests to identify their most fertile days. Their unique database and advanced algorithms significantly increase the accuracy of this reusable test. Women can quickly predict when they're most likely to conceive. The saliva test is FDA-certified. For further information, visit: https://www.babyndex.eu/.

About Ximilar

Ximilar is a software company that helps businesses make better use of image data with artificial intelligence (AI) and machine learning. It focuses mainly on computer vision, image recognition, and visual search. Ximilar provides a computer vision platform for building custom deep learning visual AI models and creates professional custom solutions related to image recognition, object detection, and more. For further information, visit: https://www.ximilar.com/.

Learn More

You may find the following resources helpful:

- **Intel® Xeon® Scalable Processors**
- **Intel® AI Builders**
- **Ximilar Flows**

Find the solution that is right for your organization. Contact your Intel representative or visit **intel.com/ai**.

[1] Babyndex patent records: https://worldwide.espacenet.com/patent/search/family/060786119/publication/WO2018002678A1?q=pn%3DUS2019192122A1

[2] https://www.reuters.com/article/us-couples-infertility-idUSBRE90A13Y20130111

[3] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6321627/

[4] The most common hormonal test is the Luteinization hormone (LH) strip test, evaluating the amount of this hormone in urine. They cost around 1-1.50 USD per one disposable test, there are usually 3-6 tests in a pack and women usually use these disposable tests several days a month. Women with irregular cycle must test more frequently. One week of testing: 7-14 USD = 28-56 USD monthly = 336-672 USD a year. Ovulation microscopes cost 30-50 USD and can be used forever. There are double hormone urine tests, but they tend to be even more expensive. Unfortunately, many women with irregular cycles buy the cheaper LH tests.

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