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# MODELS AND METHODS FOR QUALITY EVALUATION OF EMBRYOS

*The goal of this work consists in research of existing models and methods of for quality evaluation of animals' embryos and obtaining of software system that estimates its internal and external diameter, width, and shape factor of the embryo in order to assess its quality. The objects of study are models, methods, algorithms and computer technologies for solving of the problems of quality evaluation of animals' embryos and its characteristics.*

***Keywords:*** *quality evaluation, segmentation, metrization, anymals embryos, error, shape.*

## Introduction

The background of this work is based on remarkable similarity in the appearance of groups of animal species during periods of their embryonic development. This classic observation has long been viewed as an emphatic realization of the principle of common descent. Despite the importance of embryonic conservation as a unifying concept, models seeking to predict and explain different patterns of conservation have remained in contention. Here, we focus on early embryonic development and discuss several lines of evidence, from recent molecular data, through developmental networks to life-history strategies [1], that indicate that early animal embryos are not highly conserved. Bringing this evidence together, we argue that the nature of early development often reflects adaptation to diverse ecological niches. Finally, we synthesize old and new ideas to propose a model that accounts for the evolutionary process by which embryos have come to be conserved.

The subjects of the research are models, methods, algorithms and computer technologies for solving of the problems of quality evaluation of animals' embryos and its characteristics.

The purpose and objectives of the study are models and the concepts of a conserved phenotypic period has not been universal. Comparative studies of vertebrate embryos, led by Michael Richardson, have shown that there is variation in the timing of appearance, relative shape and number of certain structures during the phenotypic period. The authors argued that, although vertebrate embryos share many features of their body plan during the phenotypic period, heterophony is so widespread that this period ought to be viewed instead as an archetype that, although useful as an organizing concept, is not observable as a clearly defined period of embryonic development[2]. In addition, Richardson suggested that changes during the phenotypic period are

more important evolutionarily precisely because they often have significant impacts upon adult morphology [3]; this is known as the adaptive penetrance model. Other studies focusing on changes in the ranked order of developmental events have concluded that there is no evidence for any pattern of conservation during embryogenesis. Now in the 21st century, comparative embryology is being tackled using the tools of the post-genomic era. Several studies taking a molecular approach to the question of embryonic conservation have brought with them a more quantitative methodology to the traditionally qualitative discipline of comparative embryology. Whereas several of these studies have provided support for a molecular signature of conservation during the phenotypic period, others have instead found support for conservation at the earliest stages of development. Given the resurgence of interest in this field, we believe this is a propitious moment to revisit the classic ideas and more recent models put forward to explain embryonic conservation.

## Statement of the problem

Based on the research of models and methods for quality evaluation of animals' embryos [4] development of method for quality evaluation of animals' embryos. For different kinds of application it is necessary to highlight and metrization the input image in order to provide evaluation of characteristics of the embryo in micrometers. In process of evaluation of objects it's mandatory to select boundaries of the external shell of the embryo to the averaged estimation of its internal and external diameter, width, and shape factor of the embryo in order to assess its quality.

During the work we will work with blastomeres, so one of the main task is to select of the boundary of the blastomeres to estimating the fill factor [5]. Developed method of solving this problem should be computationally efficient. After developing of this method, it's necessary to implement practical realization of the developed method for quality evaluation of animals' embryos.

## Model for quality evaluation of animal's embryo

On the Fig. 1 initial blastocysts are given a numerical score from 1 to 6 based on their degree of expansion and hatching status: Fig. 1.1 – early blastocyst; the blastocoel being less than half the volume of the embryo; Fig. 1.2 – blastocyst; the blastocoel being greater than or equal to half of the volume of the embryo; Fig. 1.3 – full blastocyst; the blastocoel completely fills the embryo; Fig. 1.4 – expanded blastocyst; the blastocoel volume is now larger than that of the early embryo and the zona is thinning; Fig. 1.5 – hatching blastocyst; the trophectoderm has started to herniate though the zona; Fig. 1.6 - hatched blastocyst; the blastocyst has completely escaped from the zona. The initial phase of the assessment can be performed on a dissection microscope.

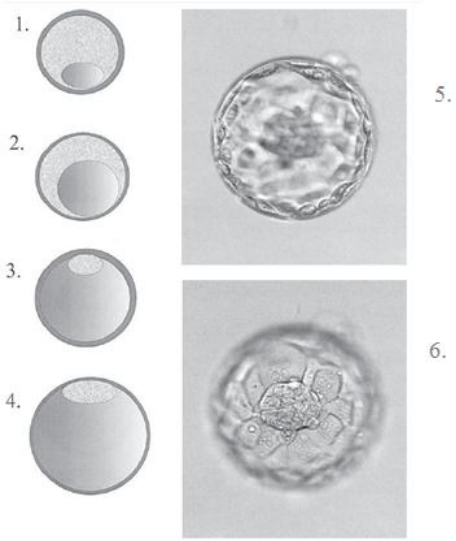



Fig. 1. Blastocyst scoring system used to select embryos for transfer

## Method for quality evaluation of animal's embryo

Method for evaluating the quality of embryo consists of 3 Algorithms.

Algorithm 1. Metrization of space consists of the following steps.

Step 1. Threshold segmentation of pixels. The first step is the threshold segmentation of black pixels on the image. Highlighted from a set of pixels, belong to picture, or to a signature on it.

Step 2. Construction. For the construction of connected objects from segmented black pixels (which are identified with the picture or signatures on it) the method of the waves applied.

Step 3. Identification. After applying of the wave method we estimate areas of obtained connected sets and then choose the one which has the largest area. This is a connected set of black pixels. It's saved and its pixels receive a particular label. The remaining connected sets of black pixels represent the image of numbers and letters to sign, located above the picture. These sets are not saving, their pixels receive a special label.

Step 4. Metrization of space [6]. After the identification the metrization of space is as follows:

1) estimate the width $s$ of the picture in pixels,

2) define the value $h = 100/s$ that determines the number of micrometers per pixel.

Then, knowing the ratio $h = 100/s$, we can estimate the actual size of segmented objects on the picture.

Step 5. End.

Algorithm 2. Finding the boundaries of the embryo consists of the following steps.

Step 1. Construction of a background standard. On the first stage, based on the background luminances of

pixels disposed at the corners of an input image (without black pixels and signature above it) builds the regression equation

$$f(x,y) = ax + by + c .$$

This equation gives the standard distribution of the background brightness.

Step 2. Threshold segmentation of embryo pixels. For each pixel of the input image with the coordinates $(x,y)$ and brightness $b(x,y)$ (without black pixels and signature above it) is estimated the variance

$$D(x,y) = \left|b(x,y) - (ax + by + c)\right| .$$

After this the condition is tested

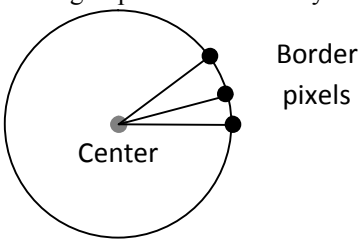
$$D(x,y) < T .$$

If this condition is satisfied, the pixel belongs to the background, otherwise to the object.

Step 3. The construction of the embryo. For the construction of connected objects from segmented pixels we apply the method of waves.

Step 4. Identification of embryo. After applying of the wave method we estimate obtained connected sets and then choose the one which has the largest area. This connected set of pixels is an embryo. It saved and its pixels receive a particular label.

Step 5. Finding the boundary of the embryo. The boundary of the embryo is in the course of the radial scan line emanating from its center point of the embryo $(x_0, y_0)$ in the form of a maximum length of all segments consisting of pixels of the embryo.




Step 6. End.

Algorithm 3. Assessing the quality of the embryo consists of the following steps.

Step 1. Approximation of the embryo's boundary. The average length of the segment connecting the center and the border of the embryo, gives us the radius of the circle r ,

$$r = \frac{1}{n}\sum_{i=1}^{n} len_i ,$$

$$len = \sqrt{(x - x_0)^2 + (y - y_0)^2} ,$$

which approximates the boundary of the embryo

$$(x - x_0) + (y - y_0) = r^2 .$$

Step 2. Assessing the quality of the embryo. Embryo quality is estimated by the standard deviation

$$Q = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (len_i - r)^2} .$$

Step 3. End.

On the basis of developed models and method was developed computer system "Embryo" designed to determine the type and calculation of certain physical and mechanical characteristics of the embryos of animals in an interactive mode. At the same time to improve the perception of the results of the system are displayed in text and graphic view.

To show the main functions of the program on the Fig. 2 is shown use case diagram. A use case diagram its simplest representation of a user's interaction with the system and depicting the specifications of a use case. A use case diagram can portray the different types of users of a system and the various ways that they interact with the system. This type of diagram is typically used in conjunction with the textual use case and will often be accompanied by other types of diagrams as well.

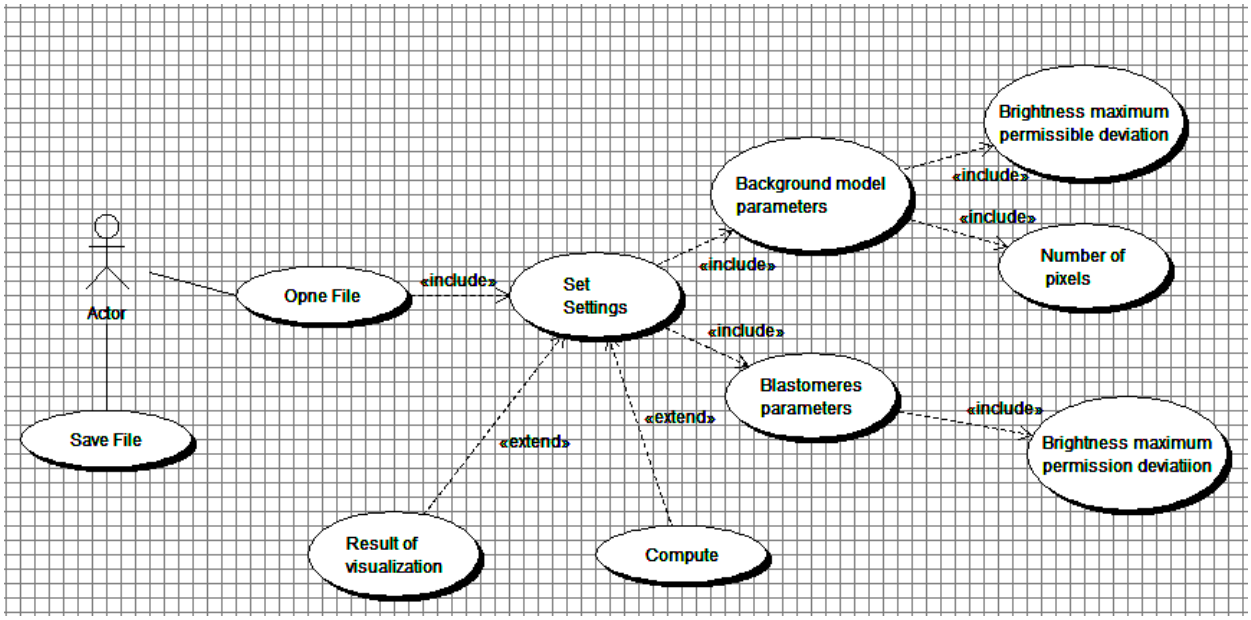



Fig. 2. Use case diagram

## Conclusion

There is a remarkable similarity in the appearance of groups of animal species during periods of their embryonic development. This classic observation has long been viewed as an emphatic realization of the principle of common descent. Despite the importance of embryonic conservation [7] as a unifying concept, models seeking to predict and explain different patterns of conservation have remained in contention. Here, we focus on early embryonic development and discuss several lines of evidence, from recent molecular data, through developmental networks to life-history strategies, that indicate that early animal embryos are not highly conserved. Bringing this evidence together, we argue that the nature of early development often reflects adaptation to diverse ecological niches [8]. Finally, we synthesize old and new ideas to propose a model that accounts for the evolutionary process by which embryos have come to be conserved.

During the research were analyzed existing models and methods for quality evaluation of animals' embryos. In the process of analysis was identified the advantages and disadvantages of each method. As a result, the problem has been formulated.

On the basis of analysis was developed the model and method for quality evaluation of animals' embryos [9]. Model and method allows to evaluate animals' embryos and their characteristics.

Using this method, which consist of three algorithms was developed computer system for quality evaluation of animals' embryos. This system gives next possibilities selection and metrization of input image, selection boundaries of the external shell of the embryo to the averaged estimation of its internal and external diameter, width, and shape factor of the embryo in order to assess its quality.

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### МОДЕЛІ І МЕТОДИ ДЛЯ ЯКІСНОЇ ОЦІНКИ ЕМБРІОНІВ

А.С. Чуприна, Аль Дулаімі Ахмед Абдулмунем

*Мета даної роботи полягає у дослідженні існуючих моделей і методів для оцінки якості ембріонів тварин і отриманні програмної системи, яка оцінює внутрішній і зовнішній діаметр, ширину і коефіцієнт форми ембріона з метою оцінки його якості. Об'єктами дослідження є моделі, методи, алгоритми та комп'ютерні технології для вирішення задачі оцінки якості ембріонів тварин і їх характеристик.*

***Ключові слова:*** *якісна оцінка, сегментація, ембріони тварин, помилка, форма.*

### МОДЕЛИ И МЕТОДЫ ДЛЯ КАЧЕСТВЕННОЙ ОЦЕНКИ ЭМБРИОНОВ

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*Цель данной работы заключается в исследовании существующих моделей и методов для оценки качества эмбрионов животных и получение программной системы, которая оценивает внутренний и внешний диаметр, ширину и коэффициенту формы эмбриона с целью оценки его качества. Объектами исследования являются модели, методы, алгоритмы и компьютерные технологии для решения задачи оценки качества эмбрионов животных и их характеристик.*

***Ключевые слова:*** *качественная оценка, сегментация, эмбрионы животных, ошибка, форма.*