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Quantum Generators: Model Design for Predicting and Driving Cell Growth in Natural Crop Tissues.

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ABSTRACT

Quantum Generators is a means of achieving mass food production with short production cycles, and when and where required by means of machines rather than land based farming which has serious limitations. The process for agricultural practices for plant growth in different stages is simulated in a machine with a capacity to produce multiple seeds from one seed input using computational models of multiplication (generating multiple copies of kernel in repetition). In this paper, we present a method to predict cell growth of natural tissues of crops by looking at how cells change to understand what is driving this growth. Here the method looked at gene expression profiles which showed the cell's process of assembling proteins and the ability of the matter to grow and remodel in response to stimuli. We checked our approach by understanding and predicting growth of living systems such as skin and tumor growth which is one of the most important challenges in cellmechanics. Our study given us more information about how cells grow and their overall response in terms of shape evolution or mass addition with mathematical modelling and advanced methods. While this need to be tested using natural crop cells, however it could be promising for us in achieving quantum generation.

INTRODUCTION

A **Quantum** (plural quanta) is the minimum amount of any physical entity (physical property) involved in an interaction. On the other hand, **Generators** don't actually create anything instead, they generate quantity prescribed by physical property through multiplication to produce high quality products on a mass scale. The aim of Quantum Generators is to produce multiple seeds from one seed at high seed rate to produce a particular class of food grains from specific class of **seed** on mass scale by means of machine rather than land farming.

The process for agricultural practices include preparation of soil, seed sowing, watering, adding manure and fertilizers, irrigation and harvesting. However, if we create same conditions as soil germination, special watering, fertilizers addition and

plant growth in different stages in a machine with a capacity to produce multiple seeds from one seed input using computational models of multiplication(generating multiple copies of kernel in repetition) then we will be closure to achieving mass food production by means of quantum generators(machine generated) rather than traditional land based farming which has very serious limitations such as large space requirements, uncontrolled contaminants, etc. The development of Quantum Generators requires specialized knowledge in many fields including Cell Biology, Nanotechnology, 3D Cellprinting, Computing, Soil germination and initially they may be big occupying significantly large space and subsequently small enough to be placed on roof-tops.

The Quantum Generators help world meet the food needs of a growing population while simultaneously providing opportunities and revenue streams for farmers. This is crucial in order to grow enough food for growing populations without needing to expand farmland into wetlands, forests, or other important natural ecosystems. The Quantum Generators use significantly less space compared to farmland and also results in increased yield per square foot with short production cycles, reduced cost of cultivation besides easing storage and transportation requirements.

In addition, Quantum Generators Could Eliminate Agricultural Losses arising out of Cyclones, Floods, Insects, Pests, Droughts, Poor Harvest, Soil Contamination, Land Degradation, Wild Animals, Hailstorms, etc.

Quantum generators could be used to produce most important *food* crop *like* rice, wheat and maize on a mass scale and on-demand when and where required.

Computers and Smartphones have become part of our lives and Quantum Generators could also become very much part of our routine due to its potential benefits in enhancing food production and generating food on-demand wherever required by bringing critical advanced technologies into the farmland practices.

3D Bioprinting

3D Bioprinting is a form of additive manufacturing that uses cells and other biocompatible materials known as bioinks, to print living structures layer-by-layer which mimic the behavior of natural living systems. Three dimensional bioprinting is the utilization of 3D printing–like techniques to combine cells, growth factors, and biomaterials to fabricate biomedical parts that maximally imitate natural tissue characteristics.

Bioprinting (also known as **3D bioprinting**) is combination of **3D printing** with biomaterials to replicate parts that imitate natural tissues, bones, and blood vessels in the body. It is mainly used in connection with drug research and most recently as cell scaffolds to help repair damaged ligaments and joints. In this paper, we are looking at natural tissues related to food crops like rice, wheat or maize.

ARCHITECTURE

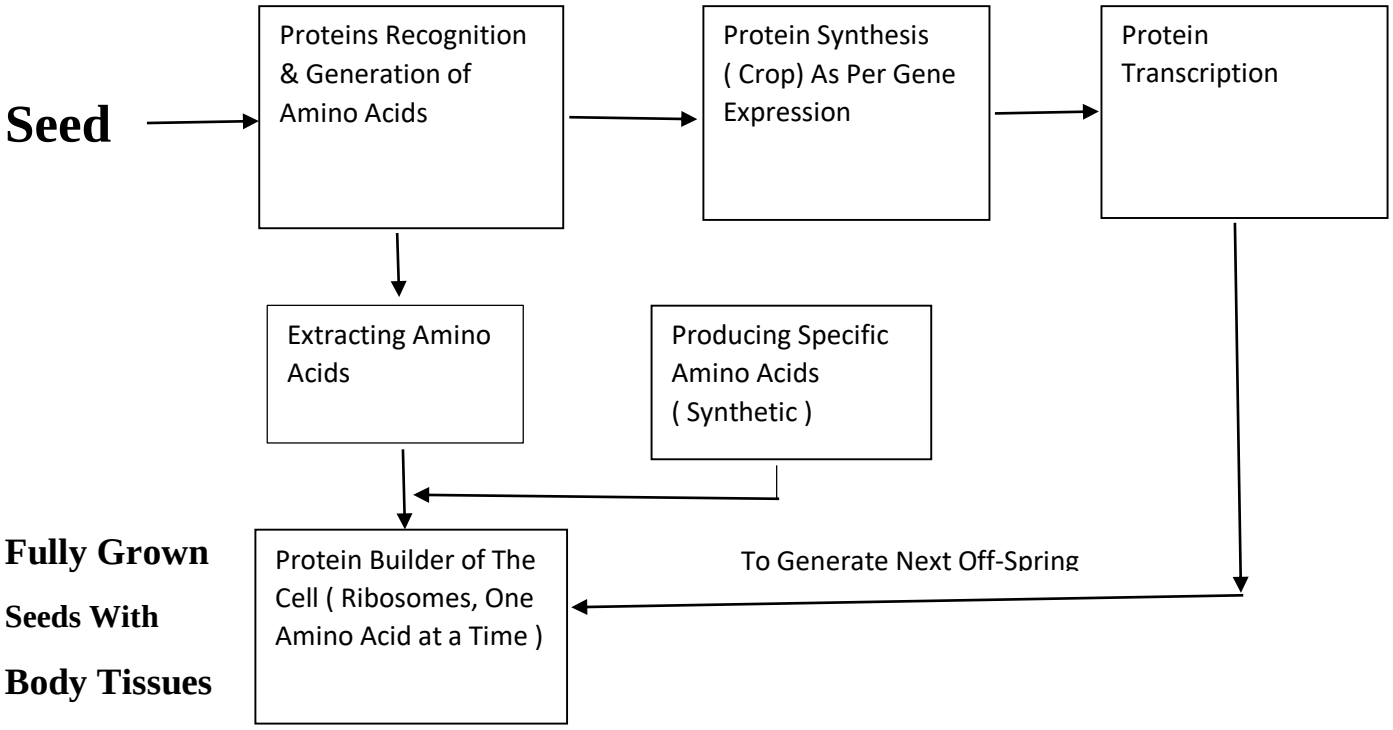

Fig 1. Process Flow Diagram of Seed Builder

Protein from input seeds is broken down into individual amino acids which are reassembled by Quantum Generating ribosomes into proteins that Crop cells need to be generated. The information to produce a protein is encoded in the **cell's** DNA. When a protein is produced, a copy of the DNA is made (called mRNA) and this copy is transported to a ribosome.

Protein **synthesis** is the process used by the QG(Quantum Generator) to make proteins. The first step of protein **synthesis** is called Transcription. It occurs in the nucleus. During transcription, mRNA transcribes (copies) DNA.

Body tissues **grow** by increasing the number of cells that make them up. Every **cell** in the crop body contains protein. The basic structure of protein is a chain of amino acids. We need protein in our diet to help human body repair cells and make new ones. Protein is also important for growth and development in children, teens, and pregnant women.

The major steps in protein synthesis are:

- DNA unzips in the nucleus.
- mRNA nucleotides transcribe the complementary DNA message.
- mRNA leaves nucleus and goes to ribosome.
- mRNA attaches to ribosome and first codon is read.
- tRNA brings in proper amino acid from cytoplasm.
- a second tRNA brings in new amino acid.

The journey from gene to **protein** is complex and tightly controlled within each cell. It consists of two major **steps**: transcription and translation. Together, transcription and translation are known as gene expression.

Protein synthesis is the process in which **cells make proteins**. It occurs in two stages: transcription and translation. Transcription is the transfer of genetic instructions in DNA to mRNA in the nucleus. Translation occurs at the ribosome, which consists of rRNA and proteins**.**

Ribosomes are the protein builders or the protein synthesizers of the cell. They are like construction guys who connect one amino acid at a time and build long chains. Ribosomes are special because they are found in both prokaryotes and eukaryotes.

Ribosomes, large complexes of **protein** and ribonucleic acid (RNA), are the cellular organelles responsible for protein synthesis. They receive their “orders” for protein synthesis from the nucleus where the DNA is transcribed into messenger RNA (mRNA).

During the **process** of transcription, the information stored in a gene's DNA is passed to a similar molecule called RNA (ribonucleic acid) in the cell nucleus. A type of RNA called transfer RNA (tRNA) assembles the protein, one amino acid at a time.

Ribosomes are the sites in a **cell** in which **protein** synthesis takes place. Cells have many ribosomes, and the exact number depends on how active a particular cell is in synthesizing proteins. For example, rapidly growing cells usually have a large number of ribosomes.

Amino acids can be produced by breaking down proteins, known as the extraction method. However, the amount of amino acids in the source protein limits the amount of

amino acids made. Extraction is not good for making mass quantities of specific amino acids**.** So Synthetic Methods of making amino acids is necessary in protein synthesis.

The Quantum Generator contains pre-programmed Protein Synthesizer relevant to specific Crop/Tissue which essentially reassembles ribosomes (Sites in a Cell) into proteins that your crop cells need. The sequence and information to produce a protein is encoded in the synthesizer of Quantum Generator.

Foundations of Cell Growth

Biological cells, and tissues exhibit a remarkable ability to grow by changing their mass and remodel by changing their internal structure. Growth and remodelling enable normal development and somatic growth, they drive adaptations to changes in external stimuli, and they mediate many responses to interventions. In many cases, growth and remodelling processes depend strongly on mechanical factors and the associated mechanobiological response at the cellular level. Experience reveals that mathematical modelling of growth and remodelling processes can provide valuable insight into the basic biology, help guide the design and interpretation of appropriate actions, a inform planning for intervention. In this section, we present some of the conceptual foundations upon which theories of growth and remodelling have emerged focusing mainly on soft tissues.

The growth mechanics is essentially employing simple relationships between forces acting on growing organs and organisms and their overall response in terms of shape evolution or mass addition.

Mechanobiology is the study of biological responses by cells to mechanical stimuli. Modern mechanobiology emerged following advances in mammalian cell culture and molecular and cell biology, noting that many biological responses to changes in the mechanical environment of the cell are mediated by changes in gene expression. While biomechanics includes diverse areas ranging from protein folding to gait analysis, continuum biomechanics focuses on cells, tissues and organs and naturally complements studies in mechanobiology: one exploits advances in mechanics and the other advances in biology, while both seek to understand questions of structure–function relationships and growth and remodelling throughout the cycle of life.

Finite growth

The theory of finite growth was formalized and rapidly gained popularity with the use of computational methods to solve the underlying set of governing equations. In contrast to the traditional theory of finite elasticity that consists of the classical set of kinematic,

balance and constitutive relations, the theory of finite kinematic growth requires two additional sets of equations: kinematic and kinetic equations of growth. Those two relations have to be prescribed constitutively to close the system of governing equations and thus are specific to the type of physiological system. The theory of finite growth is based on a particular multiplicative decomposition of the deformation gradient. Consider a motion $\boldsymbol{\varphi}: \mathrm{B}0 \rightarrow \mathrm{B}t$ that maps an initial reference configuration B0 to a current configuration Bt via $\boldsymbol{x}(\boldsymbol{X},t)=\boldsymbol{\varphi}(\boldsymbol{X},t)$, where $\boldsymbol{x}(\boldsymbol{X},t)$ is the position at time t of the material point originally located at $\boldsymbol{X}$ at time $t = 0$. The main idea is to decompose the deformation gradient, $\boldsymbol{F}=\nabla\boldsymbol{\varphi}=\partial\boldsymbol{x}/\partial\boldsymbol{X}$, into an elastic part $\boldsymbol{F}^{\boldsymbol{e}}$ and a growth part $\boldsymbol{F}^{\boldsymbol{g}}$

$$\boldsymbol{F}=\boldsymbol{F}^{\boldsymbol{e}}\cdot\boldsymbol{F}^{\boldsymbol{g}}.$$

The growth tensor $\boldsymbol{F}^{\boldsymbol{g}}$ effectively represents the addition or the subtraction of mass to a local volume element. We typically prescribe $\boldsymbol{F}^{\boldsymbol{g}}$ constitutively, either directly or in rate form to characterize the evolution of growth. Typically, only the elastic contributions $\boldsymbol{F}^{\boldsymbol{e}}$ generate mechanical stresses that we can understand growth via a series of stress-free configurations. In the simplest case, we can assume a stress–strain behavior of neo-Hookean type with Cauchy stress

$$\boldsymbol{\sigma}=[\lambda\ln(\det(\boldsymbol{F}^{\boldsymbol{e}}))-\mu]\boldsymbol{I}+\mu\boldsymbol{F}^{\boldsymbol{e}}\cdot(\boldsymbol{F}^{\boldsymbol{e}})^{\mathrm{t}},$$

where λ and μ are the elastic Lamé constants and $\boldsymbol{I}$ is the second-order identity tensor. Similar to the classical theory of finite elasticity, this stress enters the linear momentum equation in equilibrium

$$\mathrm{div}(\boldsymbol{\sigma})+\rho\boldsymbol{b}=0,$$

where ρ is the overall mass density and $\boldsymbol{b}$ is the body force. Provided we know the growth tensor $\boldsymbol{F}^{\boldsymbol{g}}$, we can solve this equation, with appropriate boundary conditions, either analytically for simple geometries or numerically using nonlinear finite-element solvers. A defining feature of the theory of finite growth is the series of *incompatible* growth configurations expressed mathematically by the growth tensor $\boldsymbol{F}^{\boldsymbol{g}}$

Surface growth

In this, we focus primarily on volume growth, which assumes an addition or subtraction of mass within regions of existing tissue. Alternatively, tissues may grow by surface growth, which assumes an addition of material at the tissue surface Γ. Typical examples are growing horns, tusks, shells or bones. Surface growth models also often adopt a multiplicative decomposition of the deformation gradient, $\boldsymbol{F}=\boldsymbol{F}^{\boldsymbol{e}}\cdot\boldsymbol{F}^{\boldsymbol{g}}$, into an elastic part $\boldsymbol{F}^{\boldsymbol{e}}$ and a growth part $\boldsymbol{F}^{\boldsymbol{g}}$ or an additive decomposition of the material velocity $\boldsymbol{V}=\boldsymbol{V}^{\Gamma}+\boldsymbol{V}^{\boldsymbol{g}}$ into the surface velocity $\boldsymbol{V}^{\Gamma}$ the velocity of the grown material $\boldsymbol{V}^{\boldsymbol{g}}$.

Skin: growing new seed skin

Skin is interface with the outside world. In its natural environment, it displays unique mechanical characteristics including prestrain and growth. While there is general agreement on the physiological importance of these features, they remain poorly characterized mainly because they are difficult to access with standard laboratory techniques. By combining recent developments in multi-view isogeometric analysis, it is now possible to analyse skin in detail. We can quantify prestretch, deformation and growth by longitudinally and we can reconstruct the geometry from a developed surface and create parametric representations of the grown skin surface. We can analyse these representations using the theory of finite area growth based on the multiplicative decomposition of the deformation gradient $\boldsymbol{F}=\boldsymbol{F}^{\boldsymbol{e}}\cdot\boldsymbol{F}^{\boldsymbol{g}}$, into an elastic tensor $\boldsymbol{F}^{\boldsymbol{e}}$ and a growth tensor $\boldsymbol{F}^{\boldsymbol{g}}=\sqrt{\vartheta}\boldsymbol{I}+[1-\sqrt{\vartheta}]\boldsymbol{n}\otimes\boldsymbol{n}$, where ϑ defines the area growth. This model assumes that changes in thickness are purely elastic and no growth takes place in the thickness direction $\boldsymbol{n}$. Surface growth modelling of skin allows us to quantify both the amount of average area prestretch and area growth ϑ as a function of time. We can use these data to calibrate skin growth models and simulate experimental cases of skin expansion. These simulations can accurately predict the experimentally observed mechanical and structural response of skin. This living skin model can easily be generalized to arbitrary biological membranes and serve as a valuable tool to virtually manipulate living systems, simply by means of changes in their mechanical environment.

Cellular growth: nutrients and stress as regulating factors

Cells is characterized by accelerated cellular proliferation and local changes in matrix and growth of networks. The *multi-cellular spheroid* is a standard mechanobiological system for studying the uncontrolled duplication rate of a cell aggregate. A cell rounded is a cluster of cells floating in culture medium, proliferating freely in an environment with abundant nutrients. cells have the ability to self-regulate their number and they duplicate isotropically in an uncontrolled manner, producing a nearly spherical shape. In the case of free, unconstrained growth, the diameter typically exhibits an early exponential growth, followed by linear growth. The transition from one regime to the other is mainly regulated by the availability of nutrients, which, in turn, is driven by diffusion through the intercellular space. In fact, when the size of the growth $R(t)$ is smaller than the typical diffusion length, nutrient is available everywhere in the spheroid and the growth is purely volumetric, $\mathrm{d}R^3/\mathrm{d}t \simeq R^3$, and the radius increases exponentially in time, $R \simeq e^t$. Conversely, when the diameter of the spheroid is much larger than the penetration length of the nutrient, growth occurs primarily at the surface, $\mathrm{d}R^3/\mathrm{d}t \simeq R^2$, and radius increases linearly in time, $R \simeq t$. In the intermediate regime, the concentration of nutrients decays exponentially with the radius, favoring external over internal proliferation.

The QG System

Our objective is to build a target system, we need to generate the cell for the device by running synthesis and implementation on the design. The cell includes custom logic for every Compute unit in the cell container. The generation of custom compute units uses the High-Level synthesis tool, which is the computer unit generator in the application compilation flow. Therefore, it is normal for this step to run for longer period of time than the other steps in the system build flow.

After all compute units have been generated, these units are connected to the infrastructure elements provided by the target device in the solution. The infrastructure elements in a device are all of the memory, control and output data planes which the device is formulated to support an application. The environment combines the custom compute units and the base device infrastructure to generate a cell binary which is used to program the QG device during application execution.

The processing flow of application execution is given as below:-

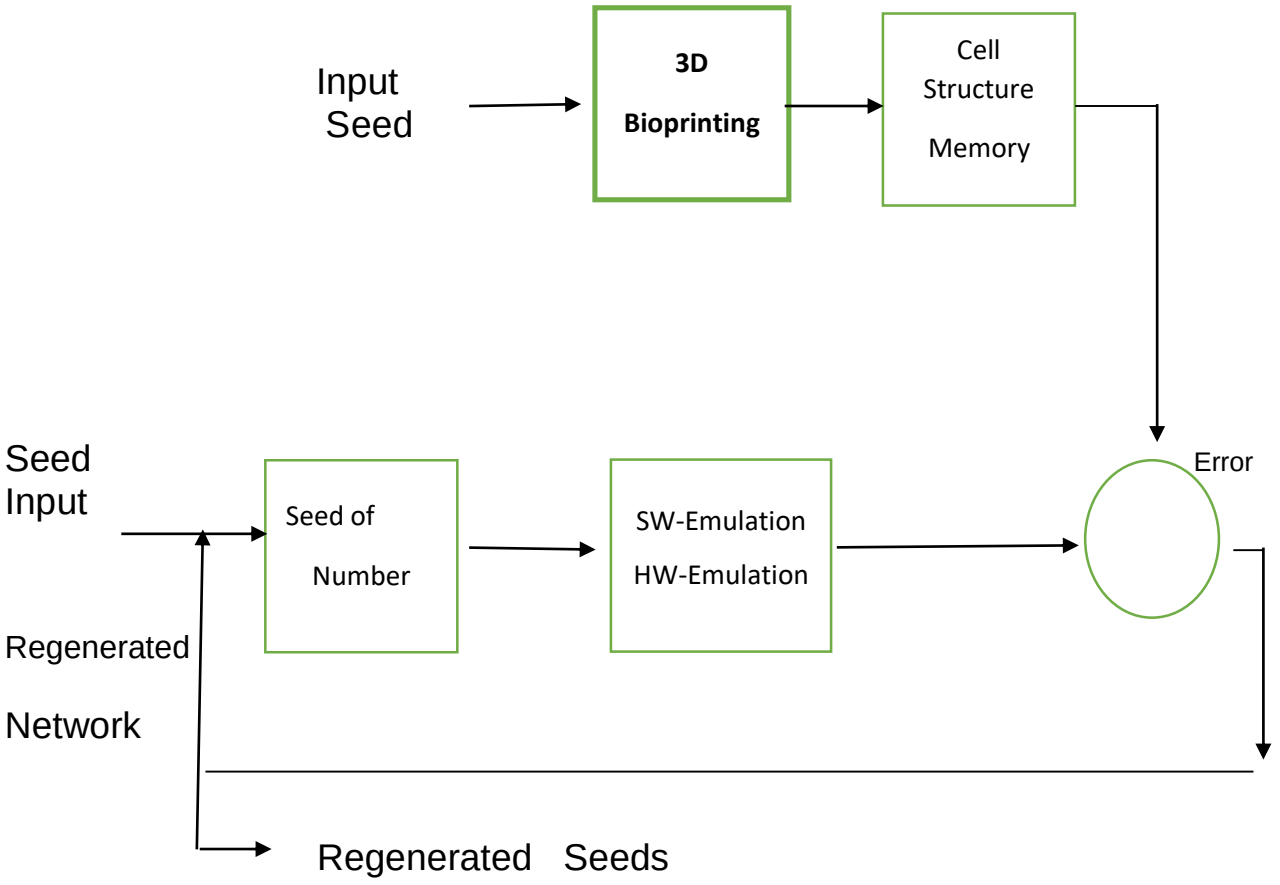

Fig. **2 Process Flow in a Quantum Generator.**

The different steps in application are as below:-

1. 3D print a seed and copy its cell structure to memory.
2. Input seed with a seed of a number required.
3. Generate a seed kernel once.
4. Compare the kernel with 3d printed cell
5. If error in seed structure, generate the kernel again.
6. Repeat many times till the seed number is met.

CONCLUSION

Quantum Generators (QG) creates new seeds iteratively using the single input seed and the process leads to a phenomenon of generating multiple copies of kernels in repetition. We presented a method to predict cell growth of natural crop tissues by understanding how the cells grow by looking at cell's process of assembling proteins and we checked our approach by understanding and predicting the growth of living systems such as skin and tumor growth. While this need to be tested using natural crop cells, however the results could be promising in achieving quantum generation.

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