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I’m pleased to present you with the third issue of SCE Science. As a leading engineering college in Israel, we adhere to core values of excellence and innovation in both teaching and research. We attribute a major importance to the role of research activity in sustaining a vibrant learning environment, and on the larger scale in contribution to formation of better society. With this in mind, we strive to promote collaboration with scientific communities and research funding agencies in Israel and worldwide.

Among the major achievements this year are the cooperation agreements with educational and research institutes abroad, increased participation of our scientists in international conferences and the receipt of funding from prestigious European funding agencies.

The efforts of our scientists bring us further to our goal of becoming the nation’s leading learning and research institute as well as the development of the Negev and the South.

Prof. Jehuda Haddad
President

In the past year, we have attained some important goals in broadening the scope of R&D activity here at SCE, including increasing public awareness of science achievements, setting foot in an international scientific community and further advancing cooperation with EU research funds.

The articles presented here reflect a rigorous work of our team of scientists and cover a range of subjects, such as innovative laser techniques, engineering projects as a basis for mechatronics research, tissue engineering strategies, propagation of electromagnetic fields, and more.

These papers are the basis for future research proposals and fruitful research that will leverage our scientific capacity and expertise. We have submitted a considerable amount of research proposals, however, the more submissions, the higher our chances for success.

In the new research year, we will work on submitting more proposals, publishing more articles and gaining more recognition at conferences. One of the major goals this year is to increase our presence in the global scientific community and establish national and international research partnerships and collaborations.

Dr. Amir Eliezer
Dean, The Authority for Research & Development
The establishment of in vitro technologies and strategies for growing oocytes to maturity from the most immature follicle (the primordial follicle) is a necessity in clinical practice, particularly for preservation of the fertility of patients who are about to undergo cancer treatments. Among the limited options currently available are emergency in vitro fertilization and ovarian tissue cryopreservation and, autotransplantation. The latter may increase the risk of reintroduction of hematologic or disseminated malignancies. The ability to mature infant follicles into ovulating follicles eliminates the potential of reintroducing cancer cells and provides an almost unlimited number of potential oocytes for fertilization. Despite the urgent need for substitute approaches, research efforts to constitute in vitro protocols for maturating follicles, especially at immature stages, are lacking. Thus far, in vitro maturation of follicles, starting with immature follicles and ending with a healthy offspring, was achieved only in a murine model. However, anatomic and physical variation between the ovary tissue of this species and others (human, cows, and so on), prevents using these protocols. Protocols concerning non-human primates are also scarce, yet their establishment is required in order to facilitate the construction of protocols for humans. Understanding the physiological and physical requirements of the follicular entity will play a key role in the establishment of the desired protocols. Herein, the present work focuses on the development and implementation of novel biotechnological strategies that will stimulate and control the growth and maturation of primordial ovarian follicles. In order to do so, we fabricated a three-dimensional (3D) alginate scaffold and cultivated the primordial follicles within this macroporous scaffold. The alginate scaffold, fabricated from sodium alginate, a xeno-free material derived from algae, possesses important properties such as mechanical stability, biocompatibility, and hydrophilicity. In addition, it is highly porous (>90%) with a large pore size of 80-150 μm, which allows efficient mass transport (Figure 1). Collaborative studies conducted with Dr. Alon Kedem and Dr. Ariel Hourvitz from the Department of Obstetrics and Gynecology, Sheba Medical Center, and Dr. Ronit Abir from the Infertility and IVF Unit, Helen Schneider Hospital for Women, Rabin Medical Center have investigated for the first time the effectiveness of the alginate scaffold for culturing human primordial
follicles in organ culture. In this work, thin human ovarian cortical slices were placed on an alginate scaffold or on Matrigel precoated inserts (Matrigel is a basement membrane matrix, used in standard cultivation methods). The results have shown that the proportion of developing follicles after culture on alginate scaffolds was significantly higher than after culturing on Matrigel. In parallel, there were more atretic (dead) follicles in the Matrigel group than the alginate scaffold group (Kedem et. al., J Assist Reprod Genet, 2011, 28:761–769). Further studies have explored the added value of adhesion signals within the 3D scaffold, on the growth and maturation of primordial follicles. In this study, we have "decorated" the alginate scaffold with RGD and HBP adhesive peptides and seeded isolated porcine primordial and stromal cells into the scaffolds. As a control group served an unmodified alginate scaffold (which is non-adhesive to the cells). Results have shown that after three weeks of cultivation, in both groups (with a slight preference for the adhesive scaffold), a small portion of the follicular population was composed of secondary follicles (a more mature state of follicles). These findings suggest that some primordial follicles, initially being 15-20 micron in size, have managed to progress to a four-fold size increase in culture. The spatial organization of the tissue within the adhesive scaffold resembled the native tissue where follicles are embedded within spread stromal cells, whereas in the non-adhesive alginate scaffold, follicles were embedded within clusters of non-adhered stromal cells (Figure 2). The benefit of using the macroporous alginate scaffold as a maturing habitat is that 3D systems more effectively stimulate physiologic conditions, because many cellular processes in organogenesis occur exclusively in three dimensions. In addition, the ease of releasing the follicles from the scaffold after long periods of culturing make the alginate scaffold an attractive candidate for this purpose. The alginate scaffold (whether modified or non-modified) can be easily dissolved without the use of harsh chemical reagents, and follicles are easily collected from the samples. During this short process, follicles maintain their intact round-shaped structure without expelling the nested oocyte (Figure 3). In conclusion, the alginate scaffold encompasses the ability to mimic the internal architecture of living tissues and to covalently comprise molecular cues such as anchoring peptides and growth factors. When compared to the traditional cultivation methods of follicles (where follicles are cultured on two-dimensional surfaces or isolated and encapsulated within alginate beads), the alginate macroporous scaffold holds a great potential of being an attractive alternative. Further studies are focusing on additional strategies from the field of tissue engineering, to enhance the growth and maturation of primordial follicles.
The matrix structure operates through a two-dimensional system of control: a project line chain of command and a functional chain of command [1]. Within the matrix, project managers retain responsibility for developing products, while functional managers concentrate on the organization’s capability to make use of up-to-date technical knowledge. Functional managers must address different objectives and priorities than project managers. The different objectives are based on the goals of each manager type—functional managers focus on long term effectiveness while project managers concentrate on more immediate accomplishments. A balance between these often opposing forces in an organization was presumed to lead to an optimum balance between product completion and technical excellence. In matrix-based organizations, both lateral and hierarchical dimensions of matrices depend on one another, and neither stands alone. Important issues that loom high in the management of research and development (R&D) projects are those of uncertainty, ambiguity, and complexity. In any event, it is easier to accomplish work objectives in an organizational structure such as a matrix, where task loads are shifting rapidly between departments. Organizations using matrix structures were expected to keep up with new technologies while obtaining savings by employing a more efficient assignment of human and physical resources. Shortcomings in the matrices became evident as competition between functional and project managers was found to have a detrimental effect upon organizational resources [2]. Project managers seek to obtain resources to meet any unanticipated circumstance by either expanding existing capacities or contracting for services from external suppliers. In contrast, functional managers oppose indiscriminate accumulation of assets by a project. They usually reject attempts to outsource work because of possible underemployment of firm personnel. A project portfolio adds another set of disagreements when project managers compete against each other for the allocation of scarce resources. However, high intensity conflicts and an unbalanced power of influence are the most substantive failures of matrix implementation. The first category in organizational classification is the low tech case—
an environment not involving scarce resources of unique specialization. Total shared resource capacity is not a constraint, because a shortage of internal resources can be remedied through rapidly executed outsourcing. In this environment the matrices can be classified into the following fundamental types [3]:

1. Project matrices (profit/cost centers).
2. Functional matrices (megaprojects).

In project matrices power is given to project managers. The common configuration of these matrices is based on the following basic principles:

1. The project manager has full control over a project budget and is authorized to take independent make or buy decisions.
2. The functional unit manager allocates resource capacity without discrimination among projects—this principle is relevant for a high tech case but not for a low tech case, because in the latter environment each project manager is permitted to achieve full satisfaction of needed resources from outsourcing.

In functional matrices power is given to functional managers. Functional managers do not allocate resources to the projects, but rather, the resources are directly allocated to project activities, taking their criticality into consideration. The common configuration of these matrices is based on the following basic principles:

The functional manager allocates resources according to present or future internal capacity, and agrees to take external buy decisions only when this does not threaten the future employment of organizational resources.

The functional manager allocates internal resource capacity without discrimination—in the low tech case, this principle is common to both project matrices and functional matrices; the difference between these fundamental forms derives only from the ‘make internally’ or ‘buy externally’ policy (see Tab. 1).

It is clear that project managers will prefer matrices where they are authorized to take independent make or buy decisions. Project matrices provide freedom to obtain all resources that are seen as needed to implement programs. For the functional manager, the project matrices can be seen as a hindrance because they prevent reasonable planning for future employment of the organization's capacities. Functional managers seek functional matrices so they can control when and how projects are given additional resources. The different preferences of the matrices in a low tech environment are shown in Tab. 2.

<table>
<thead>
<tr>
<th>Matrices From the Aspect of …</th>
<th>Project Matrices</th>
<th>Functional Matrices</th>
</tr>
</thead>
<tbody>
<tr>
<td>The project manager (P)</td>
<td>Best matrices</td>
<td>Worst matrices</td>
</tr>
<tr>
<td>The functional manager (F)</td>
<td>Worst matrices</td>
<td>Best matrices</td>
</tr>
</tbody>
</table>

The traditional description of confrontations occurring within a matrix organization [4] is shown in Fig. 1.

The implementation of project matrices by an organization is never acceptable to functional managers (F). Their obvious preference is to pursue functional matrices. Accordingly, functional managers will act in a manner that will attempt to prevent moves to project matrices. This aspiration by functional managers will be opposed by a coalition of project managers (P) who are involved with both favored and unfavored projects. This confrontation is intrinsic to the nature of the managerial positions. Researchers suggest that because power struggles occur when managers share authority, organizations should seek ways to prevent conflict from reaching destructive heights.

We consider the high tech case as one where organizational technological specialization causes difficulties in rapidly acquiring additional resource capacities within the organization, although reinforcement by external capacities is legitimate. The allocated capacities of scarce resources are constraints that determine progress in the implementation of a project. In this environment the matrices can be classified into three fundamental types [3]:
- Project matrices
- Balanced matrices (prioritized resource allocations)
- Functional matrices

Project matrices are the same in both the high tech and low tech environments. Moreover, the basic principles of these matrices remain the same. In contrast to the low tech situation, however, in the high tech situation, resource allocation without discrimination becomes an actual alternative for the decision-maker. When the organization maintains a monopoly over scarce resources, it would have difficulty supplementing those resources through external purchase. In both low tech and high tech environments, functional matrices are based on the same principles. The balanced matrices are unique to the high tech environment. Where scarce resources are involved, an organization’s readiness and ability to purchase those resources externally may nevertheless be unable to satisfy the resource needs of the projects. Clearly, if external resources are unavailable, neither readiness nor ability to pay can fill immediate resource requirements. Limited capacities must be apportioned between favored and unfavored projects. In the balanced matrices, greater power goes to favored project managers and to functional managers who deal with unfavored project managers. The configuration of these matrices is based on two principles:

1. The functional manager allocates organizational resource capacity according to directed priorities—usually to the favored projects—while unfavored projects must manage with the remaining resources.
2. The make or buy policy is usually differential and is determined by the priority of a project.

Because of the virtual impossibility of a differential make or buy policy due to the inability to obtain further scarce resources, instead of two fundamental matrices involving differential project treatment, we define only one fundamental form. By doing this, the high tech case can be described through three fundamental matrices based on two dimensions: the make or buy policy and the priority policy (see Tab. 3).

### Tab. 3 Fundamental matrices associated with the high tech case

<table>
<thead>
<tr>
<th>Priority Policy</th>
<th>Equal Resource Allocations</th>
<th>Prioritized Resource Allocations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make or Buy Policy</td>
<td>Full satisfaction of projects' needs</td>
<td>Project matrices</td>
</tr>
<tr>
<td></td>
<td>Partial satisfaction of projects' needs</td>
<td>Functional matrices</td>
</tr>
</tbody>
</table>

A two-dimensional definition of fundamental resource policies in the high tech environment brings about a consideration of more complicated decision preferences (see Tab. 4).

### Tab. 4 The high tech case: Preferences of matrices

<table>
<thead>
<tr>
<th>Matrices From the Aspect of</th>
<th>Project Matrices</th>
<th>Balanced Matrices</th>
<th>Functional Matrices</th>
</tr>
</thead>
<tbody>
<tr>
<td>The favored project manager (H)</td>
<td>Fair matrices</td>
<td>Best matrices</td>
<td>Worst matrices</td>
</tr>
<tr>
<td>The unfavored project manager (L)</td>
<td>Best matrices</td>
<td>Worst matrices</td>
<td>Fair matrices</td>
</tr>
<tr>
<td>The functional manager (F)</td>
<td>Worst matrices</td>
<td>Fair matrices</td>
<td>Best matrices</td>
</tr>
</tbody>
</table>
In this case, competition between projects for resource allocations, especially concerning scarce resources, breaks the traditional coalition between project managers, and brings about unexpected agreement between functional managers and project managers. In a high tech situation, scarce resource capacities are constraints. These constraints reduce the attractiveness of project matrices among managers of favored projects. Project matrices offer unlimited resource capacities for normal resources, but competition for scarce resources with unfavored projects occurs. Balanced matrices create an option for favored projects to obtain scarce resources. Therefore, balanced matrices should be the preferred choice for favored project managers. Functional matrices, on the other hand, mean favored projects face a rationing of resources, and give favored project managers a good reason to reject such matrices. Project matrices are the favorite matrices for managers of unfavored projects. These matrices guarantee them a share of all resources, in contrast to balanced matrices that leave unfavored projects with a low probability of receiving scarce resources, which could lead to their failure. Despite the fact that functional matrices also aim at rationing resources, the managers of unfavored projects still prefer them to balanced matrices, because they have a better chance of receiving resources. The functional managers’ objective, because it is directed at the optimized use of available resources, makes functional matrices the most attractive. For the same reason, functional managers reject the project matrices, which are forms that prevent resource allocation planning. While matrices can be a compromise for functional managers, project managers, however, disagree on the worth of balanced matrices. This is because favored projects are not limited by the need to allocate resources to internal development, while unfavored projects, most of which are internal ventures, face difficulties as resources are pulled from them to be given to the favored, mostly sponsored, projects.

[4] argue that the high tech environment derives three confrontations within the matrix organization, as shown in Fig. 2 by adopting balanced matrices, functional managers and unfavored project managers may cooperate to oppose this move. Functional managers, on the other hand, will do everything they can to prevent project matrices. When they attempt to achieve full control over buy decisions through functional matrices, however, the traditional coalition between the favored and the unfavored project managers oppose them. But if functional managers are ready to compromise, they can achieve an agreement with the favored project managers on the adoption of balanced matrices. Of course, this is a step that will be opposed by unfavored project managers. Balanced matrices are the preferred policies for favored projects, but a hindrance for unfavored projects. Managers of unfavored projects can partner with functional managers if they agree to improve their position by moving toward functional matrices, a step that will be opposed by favored project managers. The efforts of unfavored project managers to go further, and to obtain project matrices, will be confronted by an unexpected coalition of favored project managers and functional managers.

Forrester’s ‘system dynamics’ theory [5] provides a means to understand the payoff outcomes of each player’s actions in such a complex and uncertain system. What makes using system dynamics different from other approaches to studying systems is the use of feedback loops. In its simplest sense, system dynamics focuses on information that is transmitted and returned throughout the progress of a process, and the system behaviours over time that result from those flows. The feedback loops create the nonlinearity frequently found in complex dynamic problems. Running simulations to test certain matrices on such a model enables us to study reinforcing processes—feedback flows that generate exponential growth or collapse—and balancing processes, which are feedback flows that help a system maintain stability.

![Fig. 2 The high tech case: Three fronts of confrontation](image_url)
The probability of a project meeting a scheduled due date within a fixed budget cannot be estimated for R&D projects. This is primarily because of uncertainty about the resources and time needed to complete any one activity, as well as the extent to which freed resources can be used to expedite the work of other activities. In such a situation, giving full satisfaction to all assumed project requirements at the first stage of a project may actually bring about delays. These delays are often due to an inability to meet unexpected resource requirements at later stages. This late-stage inability arises because of constrained budget conditions. In contrast, projects with only partial satisfaction of requirements may, under crisis conditions, obtain additional resources in order to prevent delays. The system dynamics model as shown in Fig. 3 enables prediction of the outcomes for each matrix being tested.

System dynamics feedback loops for alternative matrices provide the following possible results:

- The feedback loops might not contribute new information that could influence decisions regarding preferred matrices.
- The feedback loops might reveal that preferred matrices are not as advantageous as previously thought, which therefore leads to neutrality.
- The impact of the feedback loops might demonstrate that a previous position was wrong and reverse a participant’s position about which matrices to favour.

An objective function composed of one or more of a large number of objectives can be chosen for performance evaluations of the project portfolio, each of its projects, and each of its functional units. The implementation of the system dynamics model provided simulated results from which we learned:

- when organizational and market conditions necessitate increases or reductions in the influence of project managers, that is, conversion of the matrix, in order to reach improved performance of the project portfolio and/or its units.
under which terms
a) organizations can unite around
one single matrix form
b) conflicts that reduce the effective
performance of matrix structures
may be avoidable
Irrespective of the findings in the
context of the matrix forms and their
implementations in project portfolios,
a simulation can never be the
reality—it can only reflect it. These
studies assumed ‘homo economicus’
participants and a management
policy directed at the improvement of
performance of the project portfolio.
‘Noises’ such as friendship or
antagonism among participants may
change the results.
Nevertheless, these studies provide
evidence for the problematic nature
of assumptions about behaviors and
conflicts in matrix structures, and call
for further research.

References

matrix. Readings in the Management of Innovation, M.L. Tushman and W.L.
Moore eds., 504-519.


The search for optimal adjustment to organizational objectives. IEEE
Transactions on Engineering Management, EM-48(2), 144-156.

in a multi-project matrix environment: Is organizational conflict inevitable?

Studies in the Management Sciences, Legasto, A. A., Forrester, J. W. &
Lyneis, J. M. Eds., 14, 7-21.
Radio-Controlled Glider with Renewable Energy Capabilities

Introduction
Thermal columns are a natural phenomenon in which temperature differences create upward wind turbulence [1]. A radio-controlled glider with a built-in wind turbine and generator was designed and constructed as part of a 4th year engineering project at the Department of Mechanical Engineering. The glider was constructed using composite materials, which combine a high level of strength with lightweight, improving energy efficiency. The generator is intended to provide renewable energy during glides, especially when thermal columns are harnessed. Turbine design was implemented using a duct-fan model which increases air flow to the generator [2].

Design and Construction
Design considerations include three main categories: structural design, design of the wind turbine generator system, and design of an efficient circuit for energizing and recharging the relevant systems.

The glider was designed with two propellers. The driving propeller is located above the plane body. This propeller provides initial lift and the extra power required to keep the glider in the air. The wind turbine is located in the front of the glider (Fig. 1). The two main forces operating on the glider wing are lift (L) and drag (D) [3]. Lift and drag, respectively, express the forces perpendicular and parallel to the air flow along the wing. The ratio between drag and lift also indicates the distance (in meters) that can be glided through given an altitude drop of 1 meter. The main design parameter affecting drag is the aspect ratio (AR), defined as:

$$AR = \frac{b^2}{S}, \hspace{1cm} (1)$$

where b is the wing span and S is the wing area. A higher aspect ratio decreases the influence of drag induced by air flow. Strength and weight calculations lead to design of the glider with an AR of 20. The body length and wing span were...
The second test flight was performed with a complete flight recording system (logger). The logger measured the following electro-mechanical parameters: Altitude, glider speed, turbine angular velocity (RPM), power consumption, current consumption and voltage. Power consumption data indicates the glide time to be approximately 60% of the flight time. Fig. 3 shows the logger output for the glider speed, measured using GPS, and the angular velocity of the propeller.

Comparing altitude and velocity shows a rise in velocity as the glider loses altitude. This indicates the turbine ability to generate power during glides. As may be expected, the behavior of the angular velocity closely follows that of the glider speed.

Table I shows the power expected to be gained and the time that would be required to recharge the batteries. The average glider speed in this test flight was 15.7 m/sec. In order to recharge an 11.1 volt battery at the average speed, it would take approximately 2 hours to recharge 1000 mA, or 6 hours to fully recharge the glider batteries (3000 mA).

Test Flights
Two test flights were performed. The first flight was performed after construction. This flight was performed without the turbine. Fig. 2 shows the glider after landing.

The second test flight was performed with a complete flight recording system (logger). The logger measured the following electro-mechanical parameters: Altitude, glider speed, turbine angular velocity (RPM), power consumption, current consumption and voltage. Power

\[ P = \frac{\pi}{8} \rho D^3 v^3, \]  

where \( \rho \) is the air density, \( D \) is the turbine diameter, and \( v \) is the wind velocity. According to Betz' law, the actual power is lower by a factor of 0.593.

In the test flight described below, a standard, 5 blade fan, normally used in computers, was used. A 24 volt DC generator was chosen for recharging the 3-cell, 3000 mA, 11.1 volt, lithium-ion battery-pack. Recharging was successfully tested under lab conditions.

Test Flights
Two test flights were performed. The first flight was performed after construction. This flight was performed without the turbine. Fig. 2 shows the glider after landing.

Future Work
After initial design and construction, the next goal is to establish the efficiency of the turbine-generator system. A set of experiments has been designed for optimizing the turbine and the generator-to-battery circuits. These experiments were carried out as a follow-up engineering project (in 2012).

Finally, as initial tests indicated, efficient battery recharging can be obtained during glides. For that reason, a control mechanism for tracking and catching thermal columns must be designed. Also, a framework for efficient flight with mid-air recharging must be considered. The control mechanism and flight-framework design are planned as future engineering projects.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Velocity [m/sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>15.7</td>
</tr>
<tr>
<td>Power - Betz (Watt)</td>
<td>11</td>
</tr>
<tr>
<td>Voltage (V)</td>
<td>11.1</td>
</tr>
<tr>
<td>Current (mA)</td>
<td>990</td>
</tr>
<tr>
<td>Charge Time (h) (per 1000 mAh)</td>
<td>1.01</td>
</tr>
<tr>
<td>Charge Time (h) (per 3000 mAh)</td>
<td>3.03</td>
</tr>
</tbody>
</table>

References
Soil-borne fungi are considered as major pathogens to many plants and can cause severe economic damage. For example, Colletotrichum coccodes (c. coccodes) is a pathogenic fungus that causes anthracnose on tomatoes and black dot disease in potatoes. More than £5 million in losses of crops annually, in the UK alone, are caused by c. coccodes according to the British Potato Council estimates. There can be additional losses to the seed industry, particularly to the export market. According to Tsror, up to 34% of potato batches imported from Holland to Israel in 1998 were contaminated with black dot. The disease also causes indirect losses - it reduces the quality of the fruits.

Fruit quality deterioration of chilli due to anthracnose ranging from 21-47% has been reported in Sri Lanka; yield losses of 15% in Korea and about 50% in Malaysia were also reported.

In the presented work, we use spectroscopic measurements combined with pattern recognition mathematical analysis as a sensitive and effective assay for the detection and discrimination of different species of fungi. The examined fungi are Colletotrichum coccodes, Verticillium dahliae and Fusarium oxysporum strains.

Fusarium is a large fungi genus with a wide variety of species and strains that inhabits soil and vegetation. It is distributed worldwide and...
associated with both warm and cold weather. The Fusarium oxysporum species, for instance, causes the Fusarium wilt disease of plants, which appears as a leaf wilting, yellowing and eventually plant death. Verticillium dahlia causes a wilt disease in hundreds of species of eudicot plants. Many economically important plants are susceptible, including cotton, tomatoes, potatoes, eggplants, and peppers. Solanaceous crops may be infected at any age by fungi causing the Fusarium wilt and Verticillium wilt, with similar symptoms. The diseases therefore cannot be distinguished based on symptoms alone. In Figure 1a-c some pictures of plants infected by the various fungi genera studied here are shown.

Early diagnosis of phytopathogens is of great importance. It could prevent substantial economical losses due to crop damage caused by fungi diseases. It could prevent unnecessary soil fumigation or the use of fungicides and bactericides, and thus averting considerable environmental pollution. Early diagnosis is also important for detecting the origin of newly-discovered isolates, in order to treat the disease in its early stages. However, the current detection techniques for fungal pathogens are time-consuming and not always precise, primarily because of the physiological characterization of the fungi, especially when examining different strains that are decidedly similar in most of their morphological and chemical characteristics. Other techniques, such as serological assays, which are based on specific interaction between antibodies and certain pathogen proteins, and molecular techniques based on PCR (Polymerase Chain Reaction) tests are very precise, expensive and available only for a limited number of fungi. Developing these methods for detecting new fungal isolates is time-consuming, highly expensive, and not always successful.

FTIR spectroscopy, used in this study, provides detailed information about the chemical composition of cells at the molecular level, allowing for the measurement of very small samples. It is a very sensitive method with high resolution and rapid performance, which makes it highly economic as well. The infrared spectrum of any compound is known to give a unique “finger
print." In figure 2 we present the spectroscopy fingerprints of samples taken from the three fungi examined in this study. Detailed information about the spectral bands of FTIR spectra, taken from living cells, is already known. Some typical bands are also mentioned in the figure.

These qualities make FTIR spectroscopy an attractive technique for detection and identification of pathogens. Our main goal was to differentiate the fungi samples on the level of isolates, based on their infrared absorption spectra obtained using the FTIR-ATR sampling technique. Each spectroscopic fingerprint is transformed together with principle component analysis (PCA) and statistical linear discriminant analysis (LDA). In PCA the data is transformed according to the covariance between different measurements. PCA is used for dimensionality reduction and also for a rough differentiation of the measured data into different categories.

In Figure 3 the measurements are presented in the reduced space, defined by the first three principal components. This gives some order of differentiation between measurements belonging to different categories. Of course, only a partial knowledge of the category features is taken into account, but it is instructive to see the differentiation that already exists at this stage of data analysis. A more comprehensive method of differentiation is the LDA, which is a linear model that separates data into its categories by defining a linear combination of the category features.

Our preliminary data using FTIR-ATR sampling techniques shows that it is possible to differentiate between pure fungi samples at the levels of genus, species, and strains. One of our previous studies has taken the method further into a more challenging stage by applying the PCA and LDA techniques to classify six different strains of pure Fusarium oxysporum in the FTIR-ATR method. The results showed that it was possible to classify and differentiate between the strains with a success rate of 81.4%.

In another study, we investigated 18 pure isolates of three different fungi genera; six isolates of Colletotrichum coccodes, six isolates of Verticillium dahliae and six isolates of Fusarium oxysporum. Our main goal was to differentiate these fungi samples.
on the level of isolates, based on their infrared absorption spectra obtained using the FTIR-ATR sampling technique. The use of PCA (3 PCs) and LDA has achieved a 99.7% success rate. However, on the level of isolates, the best differentiation results were obtained using PCA (taking 9 principal components) and LDA for the lower wavenumber region (800-1775 cm⁻¹), with identification success rates of 87%, 85.5%, and 94.5% for the Colletotrichum, Fusarium, and Verticillium strains respectively. In principle the ATR sampling technique is similar to the FTIR-FEWS technique that we intend to use for in-vivo detection of fungal diseases using remote fiber optic probes. Thus, the good preliminary results obtained using ATR spectroscopy for fungal classification of large numbers of strains on the levels of genus, species, and isolates, is an important step towards in vivo measurements using infrared fibers. The development of such fibers enables their application for in-vivo measurements using advanced portable infrared spectrometers. These measurements will probably take only few minutes using the FTIE-FEWS technique, which is much faster than the classical microbiological methods.

**Conclusion**

There is a great potential for the use of FTIR microscopy in tandem with appropriate mathematical tools in order to obtain an easy and rapid discrimination and identification of various fungi genera, which cause a huge damage in agriculture. The simplicity of sample preparation, avoidance of chemicals (that is, costs and environmental impact), reliability, and short measurement times (<1 min) when compared to other available methods, makes the FTIR-ATR technique suitable for large scale screening of fungal samples, as well as for routine analysis. These facts also encourage the possibility of developing FTIR-ATR spectroscopy as a reliable method for rapid identification of fungal pathogens.

Combining the advantages of FTIR spectroscopy with other routinely used techniques offers the chance to improve the efficiency of fungal classification and identification. Moreover, the chemical composition of the samples can be simultaneously visualised. Hence, FTIR spectroscopy can help in understanding the complex chemical processes during fungal development and substrate degradation.

**Acknowledgements**

Financial support by SCE internal research funding is gratefully acknowledged.

This paper was based on the refereed articles listed below and references therein.


output power transmission and the output power density are improved by increasing the step's angle or the radius of the cylinder of the helix, especially in the cases of space curved waveguides. This method can be a useful tool for improving the output results in all the cases of the hollow helical waveguides and in medical.

2 THE DERIVATION

The proposed method presents a rigorous approach for the propagation of EM fields along a helical dielectric waveguide with a circular cross section. The helical circular waveguide is shown in Fig. 1(a). A general scheme of the toroidal system \((r, \theta, \zeta)\) is shown in Fig. 1(b), where \(0 \leq r \leq a + \delta_a\), and \(2a\) is the internal diameter of the cross-section, \(R\) is the radius of the cylinder, and \(\zeta\) is the coordinate along the axis of the helical waveguide. Figure 1(c) shows the rotations and translation of the orthogonal system \((\tilde{X}, \tilde{Y}, \tilde{Z})\) from point A to the orthogonal system \((X, Y, Z)\) at point k. Figure 1(d) shows the deployment of the helix depicted in Fig. 1(c).

The method employs helical coordinates (and not cylindrical coordinates), such as in the methods that considered the bending as a perturbation. The calculations are based on using Laplace and Fourier transforms, and the output fields are computed by the inverse Laplace and Fourier transforms. Laplace transform on the differential wave equations is needed to obtain the wave equations and the output fields that are expressed directly as functions of the transmitted fields at the entrance of the waveguide. Thus, the Laplace transform is necessary to obtain the comfortable and simple input-output connections of the fields. A Fourier transform is applied on the transverse dimension and the differential equations are transformed into an algebraic form. The equations describe the transfer relations between the spatial spectrum components of the output and input waves in the dielectric waveguide. The output power transmission and the output power density are improved by increasing the step's angle or the radius of the cylinder of the helix, especially in the cases of space curved waveguides. This method can be a useful tool for improving the output results in all the cases of the hollow helical waveguides and in medical.

1 INTRODUCTION

This study presents the improved method for the propagation of electromagnetic (EM) fields along a helical dielectric waveguide with a circular cross section. The method employs helical coordinates (and not cylindrical coordinates), such as in the methods that considered the bending as a perturbation. The calculations are based on using Laplace and Fourier transforms, and the output fields are computed by the inverse Laplace and Fourier transforms. Laplace transform on the differential wave equations is needed to obtain the wave equations and the output fields that are expressed directly as functions of the transmitted fields at the entrance of the waveguide. Thus, the Laplace transform is necessary to obtain the comfortable and simple input-output connections of the fields. A Fourier transform is applied on the transverse dimension and the differential equations are transformed into an algebraic form. The equations describe the transfer relations between the spatial spectrum components of the output and input waves in the dielectric waveguide. The output power transmission and the output power density are improved by increasing the step's angle or the radius of the cylinder of the helix, especially in the cases of space curved waveguides. This method can be a useful tool for improving the output results in all the cases of the hollow helical waveguides and in medical.
coordinates, such as in the methods that considered the bending as a perturbation \( \left( r/R << 1 \right) \), and the calculations are based on using Laplace and Fourier transforms. The output fields are computed by the inverse Laplace and Fourier transforms. Laplace transform on the differential wave equations is needed to obtain the wave equations (and thus also the output fields) that are expressed directly as functions of the transmitted fields at the entrance of the waveguide at \( \zeta = 0^\circ \). Thus, the Laplace transform is necessary to obtain the comfortable and simple input-output connections of the fields. The longitudinal components of the fields are expressed as a function of the longitudinal components in the Laplace transform domain. Finally, the transverse components of the fields are obtained by using the inverse Laplace transform by the residue method, for an arbitrary value of the step’s angle of the helix \( \delta_p \).

We start by finding the metric coefficients from the helical transformation of the coordinates. The helical transformation of the coordinates is achieved by two rotations and one translation, and is given in the form:

\[
\begin{pmatrix}
X \\
Y \\
Z
\end{pmatrix} =
\begin{pmatrix}
\cos(\phi_e) & -\sin(\phi_e) & 0 \\
\sin(\phi_e) & \cos(\phi_e) & 0 \\
0 & 0 & 1
\end{pmatrix}
\begin{pmatrix}
1 & 0 & 0 \\
0 & \cos(\delta_p) & -\sin(\delta_p) \\
0 & \sin(\delta_p) & \cos(\delta_p)
\end{pmatrix}
\begin{pmatrix}
r \sin \theta \\
0 \\
r \cos \theta
\end{pmatrix}
+ \begin{pmatrix}
R \cos(\phi_e) \\
0 \\
R \sin(\phi_e)
\end{pmatrix},
\]

where \( \zeta \) is the coordinate along the helix axis, \( R \) is the radius of the cylinder, \( \delta_p \) is the step’s angle of the helix (see Figs. (1(c))-(1(d))), and \( \phi_e = (\zeta \cos(\delta_p)) / R \). Likewise, \( \phi_e = \phi_e \), where \( 2a \) is the internal diameter of the cross-section of the helical waveguide, and \( \delta_m \) is the thickness of the metallic layer, as shown in Fig. 2(a).

![Figure 1: (a) The helical circular waveguide. (b) A general scheme of the toroidal system \((r, \theta, \zeta)\) and the curved waveguide. (c) Rotations and translation of the orthogonal system \((X, Y, Z)\) from point A to the orthogonal system \((X, Y, Z)\) at point K. (d) Deployment of the helix.](image)

According to Equation (1), the helical transformation of the coordinates with a circular cross section becomes

\[
X = (R + r \sin \theta) \cos(\phi_e) + r \sin(\delta_p) \cos \theta \sin(\phi_e),
\]

\[
Y = (R + r \sin \theta) \sin(\phi_e) - r \sin(\delta_p) \cos \theta \cos(\phi_e),
\]

\[
Z = r \cos \theta \cos(\delta_p) + \zeta \sin(\delta_p),
\]

where \( \phi_e = (\zeta / R) \cos(\delta_p) \), \( R \) is the radius of the cylinder, and \( (r, \theta) \) are the parameters of the cross-section. Note that \( \zeta \sin(\delta_p) = R \phi_e \tan(\delta_p) \).
The metric coefficients in the case of the helical waveguide with a circular cross section, according to Eqs. (2a)-(2c) are:

\[ h_r = 1, \quad h_\theta = r, \]  
\[ h_z = \sqrt{1 + \frac{r}{R} \sin \theta \cos^2 (\delta_\rho) + \sin^2 (\delta_\rho) \left( 1 + \frac{r^2}{R^2} \cos^2 \theta \cos^2 (\delta_\rho) \right)} \]
\[ = \sqrt{1 + \frac{2r}{R} \sin \theta \cos^2 (\delta_\rho) + \frac{r^2}{R^2} \sin^2 \theta \cos^2 (\delta_\rho) + \frac{r^2}{R^2} \cos^2 \theta \cos^2 (\delta_\rho) \sin^2 (\delta_\rho)} 
\approx 1 + \frac{r}{R} \sin \theta \cos^2 (\delta_\rho). \]  

Note that the third and the fourth terms in the root of the metric coefficient \( h_z \) are negligible in comparison to the first and the second terms when \((r/R)^2<<1\).

The method for the propagation of EM field along a helical waveguide with one bending and with a circular cross section are given in detail in Ref. [1], as a part of our derivation. Let us repeat only the main steps, in brief. The derivation is based on Maxwell’s equations for the computation of the EM field and the radiation power density at each point during propagation along a helical waveguide, with a radial dielectric profile. The wave equations for the electric and magnetic fields components are given for the inhomogeneous dielectric medium. It is necessary to find the values of \( \nabla \cdot \mathbf{E}, \nabla (\nabla \cdot \mathbf{E}), \nabla \times \mathbf{E}, \) and \( \nabla \times (\nabla \times \mathbf{E}) \) in order to obtain the value of \( \nabla^2 \mathbf{E}, \) where \( \nabla^2 \mathbf{E} = \nabla (\nabla \cdot \mathbf{E}) - \nabla \times (\nabla \times \mathbf{E}) \).

All these values are dependent on the metric coefficients (3a,b,c). The longitudinal components of the fields are developed into the Fourier-Bessel series. The transverse components of the fields are expressed as a function of the longitudinal components in the Laplace transform domain. Finally, the transverse components of the fields are expressed in a form of transfer matrix functions and are obtained by using the inverse Laplace transform by the residue method, for an arbitrary value of the step’s angle of the helix (\( \delta_\rho \)). The transverse components of the output fields are depended on the roots (zeros) of the equations \( J_1(\chi) = 0 \) and \( dJ_1(\chi)/d\chi \), where the first fifty roots (zeros) of the equations \( J_1(\chi) \) and \( dJ_1(\chi)/d\chi = 0 \) may be found in tables [2-3]. The inverse Laplace transform is performed in this study by a direct numerical integration in the Laplace transform domain by the residue method. The complex Bessel functions are computed by using NAG subroutine [4].
3 NUMERICAL RESULTS AND CONCLUSIONS

An example of the circular cross section of the helical waveguide is shown in Fig. 2(a). The main contributions of the proposed method are demonstrated in Fig. 2(b) and in Fig. 3(a)-3(d), in order to understand the influence of the step's angle (\(\delta_p\)) and the radius of the cylinder (\(R\)) on the output power transmission, for helical waveguide with a circular cross section (Fig. 2(a)). Figure 2(b) shows the influence of the step's angle (\(\delta_p\)) and the radius of the cylinder (\(R\)) on the output power transmission for helical waveguide with a circular cross section. Six results are demonstrated for six values of \(\delta_p\) (\(\delta_p = 0.0, 0.4, 0.7, 0.8, 0.9, 1.0\)), where \(\zeta = 4\) m, \(a = 1\) mm, \(w_0 = 0.06\) mm, \(n_d = 2.2\) and \(n(Ag) = 13.5 - j75.3\). For an arbitrary value of \(R\), the output power transmission is large for large values of \(\delta_p\) and decreases with decreasing the value of \(\delta_p\). On the other hand, for an arbitrary value of \(\delta_p\), the output power transmission is large for large values of \(R\) and decreases with decreasing the value of \(R\). Note that for small values of the step's angle, the radius of curvature of the helix can be approximated by the radius of the cylinder (\(R\)). In this case, the output power transmission is large for small values of the bending (1/\(R\)), and decreases with increasing the bending. Thus, this model can be a useful tool to find the parameters (\(\delta_p\) and \(R\)) which will give us the improved results (output power transmission) of a hollow waveguide in the cases of space curved waveguides.

The results of the output transverse components of the fields and the output power density (\(|S_{mn}|^2\)) (e.g., Fig. 3(a)) show the behavior of the solutions for the \(TEM_{00}\) mode in excitation, for the straight waveguide (\(R \to \infty\)). The result of the output power density (Fig. 3(a)) is compared also to the result of published experimental data [5] as shown also in Fig. 3(b). This comparison shows good agreement (a Gaussian shape) as expected, except for the secondary small propagation mode. The experimental result (Fig. 3(b)) is affected by the additional parameters (e.g., the roughness of the internal wall of the waveguide) which are not taken theoretically into account.

The output modal profile is greatly affected by the bending, and the theoretical and experimental results (Figs. 3(c)-3(d)) show that in addition to the main propagation mode, several other secondary modes and asymmetric output shape appear. The amplitude of the output power density (\(|S_{mn}|^2\)) is small as the bending radius (\(R\)) is small, and the shape is far from a Gaussian shape. This result agrees with the experimental results, but not for all the propagation modes. The experimental result (Fig. 3(d)) is affected by the bending and additional parameters (e.g., the roughness of the internal wall of the waveguide) which are not taken theoretically into account. In this example, \(a = 0.5\) mm, \(R = 0.7\) m, \(\phi = \pi/2\), and \(\zeta = 1\) m. The thickness of the dielectric layer \([d(Ag)]\) is 0.75 \(\mu\)m (Fig. 2(a)), and the minimum spot size \((w_0)\) is 0.2 mm.

The values of the refractive indices of the air, the dielectric layer (AgI) and the metallic layer (Ag) are \(n(0) = 1\), \(n(AgI) = 2.2\), and \(n(Ag) = 13.5 - j75.3\), respectively.
In both theoretical and experimental results (Figs. 3(c)-3(d)), the shapes of the output power density for the curved waveguide are not symmetric.

![Output power density images](image)

**Figure 3:** The output power density for $R \to \infty$, where $a=1\text{mm}$, $w_a=0.3\text{mm}$, and the length of the straight waveguide is 1m. 
(a) theoretical result;  
(b) experimental result. The output power density for the toroidal dielectric waveguide, where $a=0.5\text{ mm}$, $w_a=0.2\text{ mm}$, $R=0.7\text{ m}$, $\phi = \pi / 2$ and $\zeta =1\text{ m}$;  
(c) theoretical result;  
(d) experimental result. The other parameters are: $d(\text{AgI})= 0.75\text{ \mu m}$, $\lambda = 10.6\text{ \mu m}$, $n(0)= 1$, $n(\text{AgI})=2.2$, and $n(\text{Ag})= 13.5 - j 75$.

The method [1] has been derived for the propagation of EM field along a helical waveguide with one bending and with a circular cross section. The method [6] has been derived for the propagation of EM field along the toroidal waveguide that consists of two bendings in the same direction, and the main steps of the method for the two bendings were introduced, in detail, for small values of step angles. The method [7] has been generalized from a toroidal dielectric waveguide (approximately a plane curve) with two bendings to a helical waveguide (a space curved waveguide for an arbitrary value of the step’s angle of the helix) with two bendings.

These methods employ toroidal or helical coordinates (and not cylindrical coordinates, such as in the methods that considered the bending as a perturbation ($r/R<<1$)).
References


Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. The Laser is a quantum mechanical device that takes advantage of the subtle way in which atoms interact with electromagnetic radiation. If an atom is in an excited state, it may spontaneously decay into a lower state, releasing the energy difference between the two states as electromagnetic radiation. When this process, called spontaneous emission, takes place, the phase and the direction in which photons propagate are random. On the other hand, if the excited atom interacts with an external photon, one whose energy is close to the energy difference between the excited and the ground state, it may induce stimulated emission. In that case the phase and propagation direction of the emitted photon will be the same as that of the external photon. This process, known as stimulated emission, amplifies the incoming energy.

Since the invention of the laser in the 1960s by Schawlow and Townes, the requirement of ‘population inversion’ was considered to be mandatory, that is, in order to obtain net amplification, more atoms should reside in the upper state than in the lower state. As the frequency of transition between lasing levels increases, spontaneous emissions grow at a rate as the cube of the frequency of transition. This causes the excited atoms to undergo rapid downward transitions, so the medium does not reach the stage of becoming inverted. As a consequence, the realization of short-wavelength lasers becomes increasingly more difficult. This has led to a completely new approach to the problem, known as lasing without population inversion (LWI). Theoretical work has pointed out that under certain conditions it is possible to obtain lasing action even if the medium is not inverted.
Many schemes of obtaining lasing without inversion have been proposed, mostly three-level lasers. The key mechanism common to these schemes is the utilization of the principle of quantum interference and coherence. This is accomplished by using external coherent fields that induce multi-level atomic coherence. This mechanism has shown that if coherence is established between certain atomic states, different absorption processes may interfere destructively, which can lead to the reduction or even cancellation of stimulated absorption. At the same time, stimulated emission may remain intact, which leads to the possibility of gain even without population inversion. Lasing without population inversion differs from conventional lasing because the reciprocity between stimulated emission and absorption is broken. Consider the three-level ladder-type configuration depicted in Figure 1 [1] as an example to a scheme proposed for achieving LWI. \( |a\rangle, |b\rangle, \text{and} |c\rangle \) are the ground and excited states, respectively. The relevant atomic transitions are coupled to two external electromagnetic fields of frequencies \( \omega_c, \omega_p \) (coupling and probe lasers respectively) and associated Rabi frequencies (describing the strength of atom-field coupling) \( \Omega \text{ and } G \). \( \gamma's \) are spontaneous emission rates, and \( \Lambda \) describes an optical pump mechanism. Laser action takes place at the \( |b\rangle \rightarrow |a\rangle \) transition. The dynamics of the system are governed by the master equation for the density operator. There are two contributions to the gain/absorption of the \( |b\rangle \rightarrow |a\rangle \) transition (the imaginary part of the off-diagonal density matrix element, \( \Im(\rho_{ba}) \))—the conventional population inversion term (proportional to \( \Delta_p / \gamma_{cb} \)) and the quantum interference term (coherence term proportional to the off-diagonal element, \( \rho_{ab} \)). Figure 2 shows a numerical demonstration of gain without inversion. In part (a), the population difference between the lasing levels and coherence contribution to \( \Im(\rho_{ba}) \), as a function of the normalized parameter \( \Delta_p / \gamma_{cb} \) (probe field detuning, that is, deviation from resonance) was separately plotted. The contribution of population difference, as shown by the solid line, is seen to be negative. Thus, it contributes to absorption. The coherence contribution, on the other hand, is positive in a relatively broad region about the resonance and thus contributes to gain. The joined contributions of population and coherence are shown in (b). Gain is apparent in a relatively broad region about line center. This gain is without population inversion, and it is strictly due to the influence of the coherence \( \rho_{ab} \).

![Ladder Scheme](image)

**Figure 1.** Three-level ladder system. \( \Omega \) and \( G \) are the Rabi frequencies of the coupling and probe lasers respectively, \( \gamma_b \) and \( \gamma_a \) are the spontaneous emission rates, and \( \Lambda \) is the incoherent pump rate.

![Graphs](image)

**Figure 2.** Graph (a) simultaneously plots the population contribution (plotted in solid line) and coherence contribution (plotted in dashed line) to \( \Im(\rho_{ba}) \), as a function of probe detuning. Graph (b) shows the sum of the two contributions.
In a more recent study we investigated a similar system, this time one that interacted with Gaussian-shaped pulsed probe and coupling fields applied in a counterintuitive manner [2, 3]. In a counterintuitive sequence scheme, the short probe pulse is introduced prior to the application of the coupling field, in contrast to a regular sequence scheme, where both fields are introduced at the same time. Figure 3 describes such a sequence along with probe width and initiation times.

Figure 3. Counterintuitive and regular (intuitive) field sequencing. In a counterintuitive situation the probe field is applied prior to the coupling field. The order is reversed for regular or intuitive sequencing. Both fields are taken as Gaussian pulses. Coupling and probe initiation times are zero and \( r \). \( \Delta \tau_c \), \( \Delta \tau_p \) are the corresponding widths at half maximum.

The influence of varying the probe pulse width and the time delay between the initiation times of probe and coupling fields on transient probe gain was investigated. The investigation results are presented in Figure 4. The figure displays \( \mathcal{S}(\rho_{\text{eh}}) \) as a function of normalized time for various time delays \( \tau \). Below each of the latter the probe and coupling sequence (denoted by red and blue lines respectively), and their temporal variation and width, are displayed.

One can conclude that there is a critical time delay for which the two pulses are synchronized optimally, resulting in maximum probe gain. This critical time is a function of the interplay between the pulse widths, the coherence, and \( \gamma_m \). The most interesting feature eminent from the analysis is that the system exhibits a kind of "memory"; the probe pulse that is introduced first establishes the coherence \( \rho_{\text{eh}} \).

This lives long after the probe pulse practically died and when the coupling pulse arrives it interacts with it, resulting in probe gain at times for which the initial external probe pulse no longer exists.
Figure 4. $\Im(\rho_4)$ as a function of normalized time parameter for a series of time delay $\tau$.

References


Quasi-Valuations
Extending a Valuation
A valuation on a field \( F \) is a function \( \nu : F \to \Gamma \cup \{\infty\} \), where \( \Gamma \) is a totally ordered abelian group and \( \nu \) satisfies the following conditions:

1. \((A1)\) \( \nu(0) = \infty \)
2. \((A1')\) \( \nu(x) \neq \infty \) for every \( 0 \neq x \in F \);
3. \((A2)\) \( \nu(xy) = \nu(x) + \nu(y) \) for all \( x, y \in F \);
4. \((A3)\) \( \nu(x + y) \geq \min \{\nu(x), \nu(y)\} \) for all \( x, y \in F \).

Valuation theory has long been a key tool in commutative algebra, with applications in number theory and algebraic geometry. It has become a useful tool in the study of division algebras, and used in the construction of various counterexamples such as Amitsur’s construction of noncrossed products division algebras. See [Wad] for a comprehensive survey.

We study quasi-valuations, which are generalizations of valuations. A quasi-valuation on a ring \( R \) is a function \( w : R \to M \cup \{\infty\} \), where \( M \) is a totally ordered abelian monoid, to which we adjoin an element \( \infty \) greater than all elements of \( M \), and \( w \) satisfies the following properties:

1. \((B1)\) \( w(0) = \infty \);
2. \((B2)\) \( w(xy) \geq w(x) + w(y) \) for all \( x, y \in R \);
3. \((B3)\) \( w(x + y) \geq \min \{w(x), w(y)\} \) for all \( x, y \in R \).

Generalizations of the notion of valuation have been made throughout the last few decades. Knebusch and Zhang (cf. [KZ]) have studied valuations in the sense of Bourbaki [Bo, section 3]. Thus they were able, by omitting \((A1')\), to study valuations on any commutative ring rather than just on an integral domain. They defined the notion of Manis valuation (the valuation is onto the value group) and showed that an \( R \)-Prüfer ring is related to Manis valuations in much the same way that a Prüfer domain is related to valuations of its quotient field.

The minimum of a finite number of valuations with the same value group is a quasi-valuation. For example, the \( n \)-adic quasi-valuation on \( \mathbb{Q} \) (for any positive \( n \in \mathbb{Z} \)) already has been studied in [Ste]. (Stein calls it the \( n \)-adic valuation.) It is defined as follows: For any \( 0 \neq \frac{c}{d} \in \mathbb{Q} \) there exists a unique \( e \in \mathbb{Z} \) and integers \( a, b \in \mathbb{Z} \), with \( b \) positive, such that \( \frac{c}{d} = n^e \frac{a}{b} \) with \( n \mid a \), \( (n,b) = 1 \) and \( (a,b) = 1 \). Define \( w_\nu(\frac{c}{d}) = e \) and \( w_\nu(0) = \infty \).

Three main classes of rings were suggested throughout the years as the noncommutative version of a valuation ring. These three types are invariant valuation rings, total valuation rings, and Dubrovin valuation rings. They are interconnected by the following diagram:

\{invariant valuation rings\} \( \subset \) \{total valuation rings\} \( \subset \) \{Dubrovin valuation rings\}.

Morandi (cf. [Mor]) has studied Dubrovin valuation rings and their ideals. He proved that unlike a valuation on a field, the value group of a Dubrovin valuation ring \( B \) does not classify the ideals in general, but does so when \( B \) is integral over its center.

It can be shown that there are many quasi-valuations, even on \( \mathbb{Z} \), so in order
to obtain a workable theory one needs further assumptions. Morandi defines a
value function that is a quasi-valuation satisfying a few more conditions. Given
an integral Dubrovin valuation ring $B$ of a central simple algebra $S$, Morandi
shows that there is a value function $w$ on $S$ with $B$ as its value ring (the value
ring of $w$ is defined as the set of all $x \in S$ such that $w(x) \geq 0$). Morandi also
proves the converse, that if $w$ is a value function on $S$, then the value ring is an
integral Dubrovin valuation ring.

Tignol and Wadsworth (cf. [TW]) have developed a powerful theory which utilizes
filtrations. They consider the notion of gauges, which are the surmultiplicative
value functions for which the associated graded algebra is semisimple, and
which also satisfy a defectlessness condition. The gauges are defined on finite
dimensional semisimple algebras over valued fields with arbitrary value groups.
Tignol and Wadsworth also show the relation between their value functions
and Morandi’s.

Quasi-valuations generalize both value functions and gauges (the axioms of
quasi-valuations are contained in the axioms of value functions and gauges).
In [Sa] we study quasi-valuations extending a valuation on a finite field extension.
Namely, $F$ denotes a field with a valuation $v$, $O$ is the valuation ring, $E/F$ is
a finite field extension with $n = [E:F]$, and $w$ is a quasi-valuation on $E$ such
that $w|_F = v$. It turns out that the theory of such quasi-valuations is surprisingly
rich. We describe the structure of rings associated to these quasi-valuations.
We prove that these rings satisfy INC, GU, and GD over $O$; in particular, they
have the same Krull Dimension and the size of the prime spectrum is bounded.
We also prove that every such quasi-valuation is dominated by some valuation
extending $v$.

Under the assumption that the value monoid is weakly cancellative, we prove
that an exponential quasi-valuation must be of the form $w = \min\{u_1, \ldots, u_k\}$ for
valuations $u_i$ on $E$ extending $v$. We also obtain a 1:1 correspondence between
the set of all exponential quasi-valuations extending $v$ and the set of all integrally
closed quasi-valuation rings.

Moreover, we deduce that the number of exponential quasi-valuations is
bounded by $2^{[E:F]-1}$.

Given a totally ordered abelian group $\Gamma$, we present the construction of the cut
monoid $M(\Gamma)$, which is an $\mathbb{N}$-strictly ordered abelian monoid. We use the cut
monoid as the value monoid of the filter quasi-valuation. Namely, given $R$, an
algebra over $O_v$, we construct a quasi-valuation on $R$ with values inside $M(\Gamma)$;
we also construct a quasi-valuation on $R \otimes O_v$ with values inside $M(\Gamma)$,
which helps us prove our main theorem. The main theorem states that if $R \subseteq E$
satisfies $R \cap F = O$, and $E$ is the field of fractions of $R$ then $R$ and $v$ induce
the filter quasi-valuation $w_f$ on $E$ such that $R = O_{w_f}$ and $w_f$ extends $v$; thus $R$
satisfies the properties of a quasi-valuation ring.

Valuation theory is a powerful tool in commutative algebra as well as in the study
of division rings. Since a quasi-valuation is a much more flexible tool than a
valuation and exists more often, one can hope to make the quasi-valuation a
productive tool as well. Our goal is to develop a rich theory so that researchers
in other branches of mathematics can use the theory of quasi-valuations and
implement it for their own use.
References


The conference showcased the college researchers’ extensive activity and emphasized the importance of active research in sustaining quality academic teaching environment.

The Researchers Conference that aimed to present academic activity at the SCE was held in July 2012 at the initiative of SCE Research and Development Authority. In addition to presenting diverse research activities, the conference was designed to emphasize the importance the college attributes to research activities in maintaining a quality academic teaching environment. The conference was also designed to further establish the understanding that the quality of active research is largely dependent on submitting proposals to external research funds and maintaining partnerships within and outside the country and around the world.

Leverage for extensive research

SCE President, Prof. Jehuda Haddad, has welcomed the participants and underscored the importance of the research activity and the management expectations from its development and cooperation in the field. He stressed that active research contributes to the promotion of the status and recognition of SCE as well as to personal development and career advancement of the scientists. Dr. Amir Eliezer, the Dean of R&D Authority, spoke about the Authority activities and the tools it provides for the researchers. Zohar Wohlfarth Cohen, Deputy Director General, reviewed the R&D budget through the lens of Finance Division and elaborated on proper management of the budget. Prof. Avi Mendelson, Director of Academic Relations and Research at Microsoft Israel R&D Center, lectured on innovation and entrepreneurship and introduced new developments. Dr. Bob Weintraub, SCE Library Director has addressed the issues concerning cooperation with the Library.

Range of research topics

Researchers from various departments lectured on diverse research topics: Dr. Oshrat Ontman, from the Chemical Engineering Department, has talked about characterization of N-Glycosylation in red microalgae; Dr. Irit Juwiler, from the Electrical and Electronics Engineering Department, lectured on Nonlinear Optics; Dr. Michal Shahar-Goldenberg, from Chemical Engineering Department, lectured on exploring tissue engineering approaches to growth and maturation of primordial ovarian follicles; Dr. Maksim Mezhericher, from Mechanical Engineering Department, has raised the need for a new research center for engineering modeling, design and numerical simulations; Dr. Tamar Ben Bassat, from Industrial and Management Engineering Department, has lectured about initial evaluation of Za' hav program on raising awareness of road safety among children and their parents; Dr. Dagan Bakun Mazor, from Civil Engineering Department, lectured on mountain slope stability in Masada and the effects of temperature changes and seismic fluctuations; Dr. Marina Litvak and Dr. Natalia Vanetik, from Computer Engineering Department, talked about automatic creation of literature review for scientific paradigms; Prof. Semyon Levitzky, from the Mathematics Unit lectured on acoustic interaction in three-phased system- effects of Fluid Rheology; Dr. Etan Fisher, from Mechanical Engineering Department, lectured on engineering projects as a basis for Mechatronics research; Dr. Ofer Barkai, from Industrial and Management Engineering Department concluded the session with his lecture on executive wages versus company performance in various industries.

The conference reviewed the variety of research activities run by the college and set up important goals in further developing robust research. Special emphasis was placed on initiating national and international collaborations with research partners as well as increasing the volume of submissions in Israel and abroad.
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